JULY 1961

modern castings

the technology-for-profit magazine

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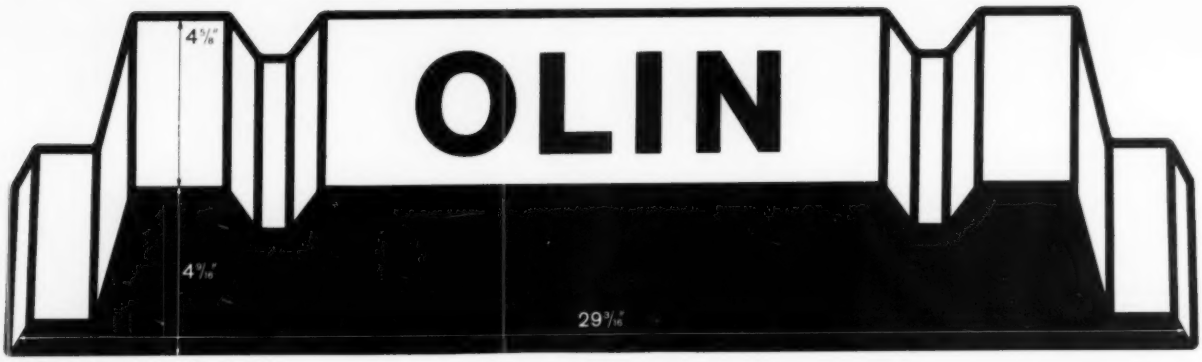
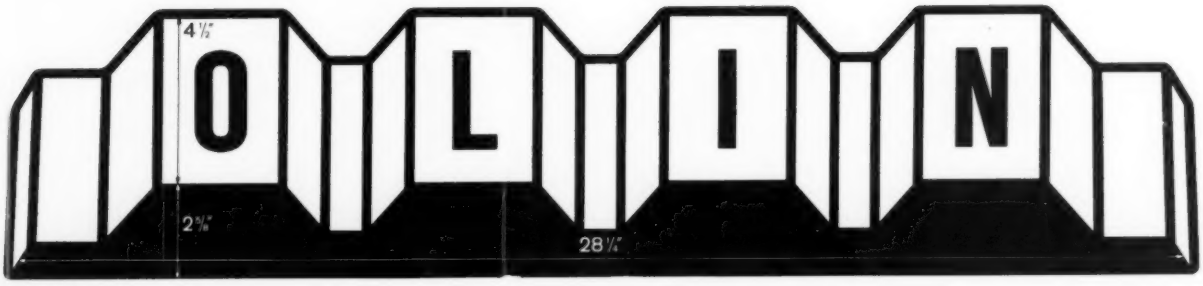


50-lb. ingot



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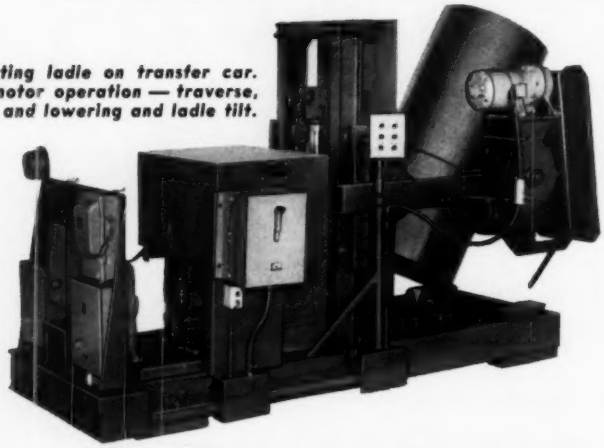
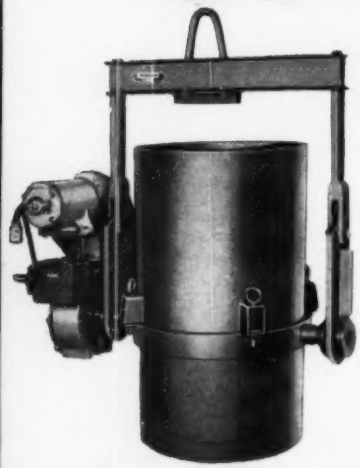


Inoculating ladle on transfer car. Three-motor operation — traverse, raising and lowering and ladle tilt.



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Circle No. 122, Pages 129-130

July 1961 Vol. 40, No. 1

modern castings

metalcasting "technology-for-profit"

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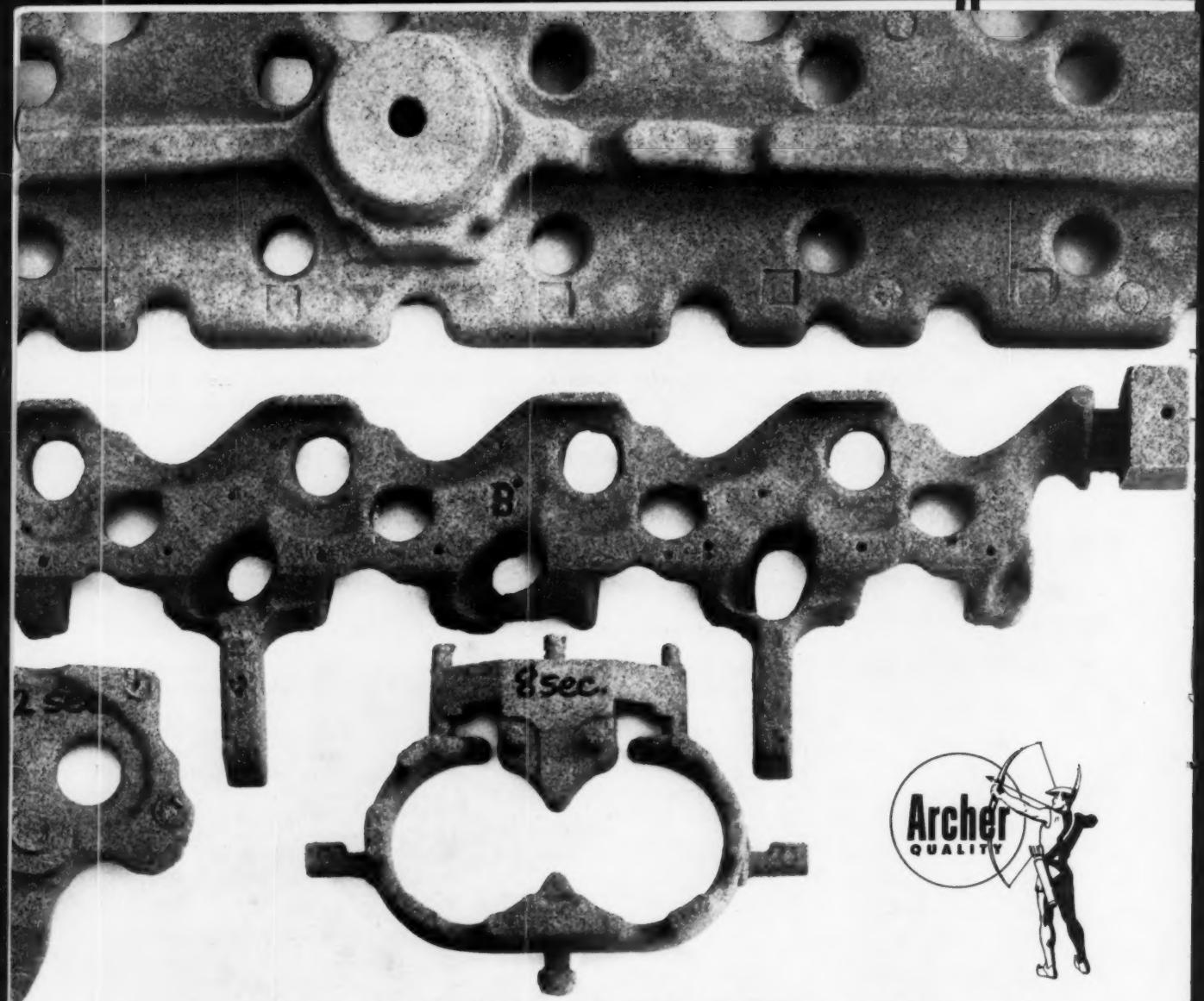

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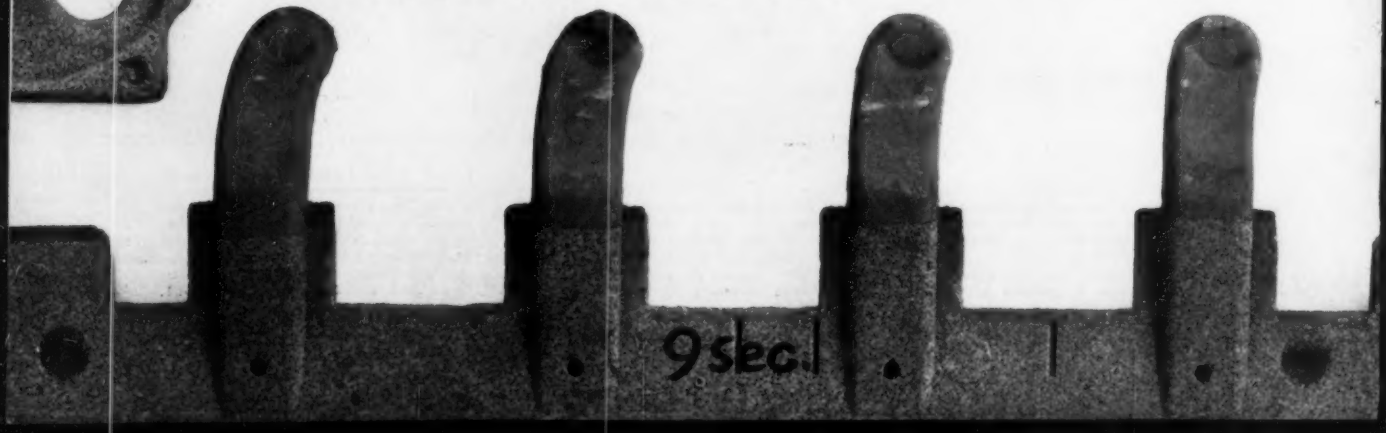

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Let's look at . . .

Grass Roots Opinion

GRASS ROOTS opinion is always important. And when it comes from the *grass roots leaders* it carries more than the usual weight. The sum of such thinking is often a valuable key to the future. With this in mind, be sure to read the second annual Chapter Officers' Trends Survey made by MODERN CASTINGS. (See Looking at Business, pages 7 and 8.)

H. E. Green

The survey covers business trends, sales efforts, operations, and purchasing intentions. We're happy to report that the outlook for the remainder of 1961 is moderate, better for 1962. Real optimism is displayed.

Also indicated—in the opinion of AFS *grass roots influentials*—is that MODERN CASTINGS is a *much* improved and *better read* magazine than 12 months ago. For instance:

. . . 72 per cent reported that their personal issues of MODERN CASTINGS are read by many other associates. This takes on added significance when it is considered that a large number of MODERN CASTINGS copies are mailed to the homes of readers rather than to their offices. (About 55 per cent reported pass-along readership last year. So the rise is substantial!)

. . . 66 per cent report they spend more than an hour or more reading an issue of MODERN CASTINGS.

. . . 93 per cent read MODERN CASTINGS regularly; 64 per cent refer to it more than once!

This indicates that the increased editorial and journalistic values put into MODERN CASTINGS this last year are well worth-while.

Interestingly enough, some 54 per cent of *grass roots influentials* either look for a specific article or column, riffle through the magazine, or start at the back!

Which leads up to this July issue. We recommend the following for your special attention:

. . . The railroads of the nation are fighting back with a modernization program that means a broadening castings market, pages 31 to 33.

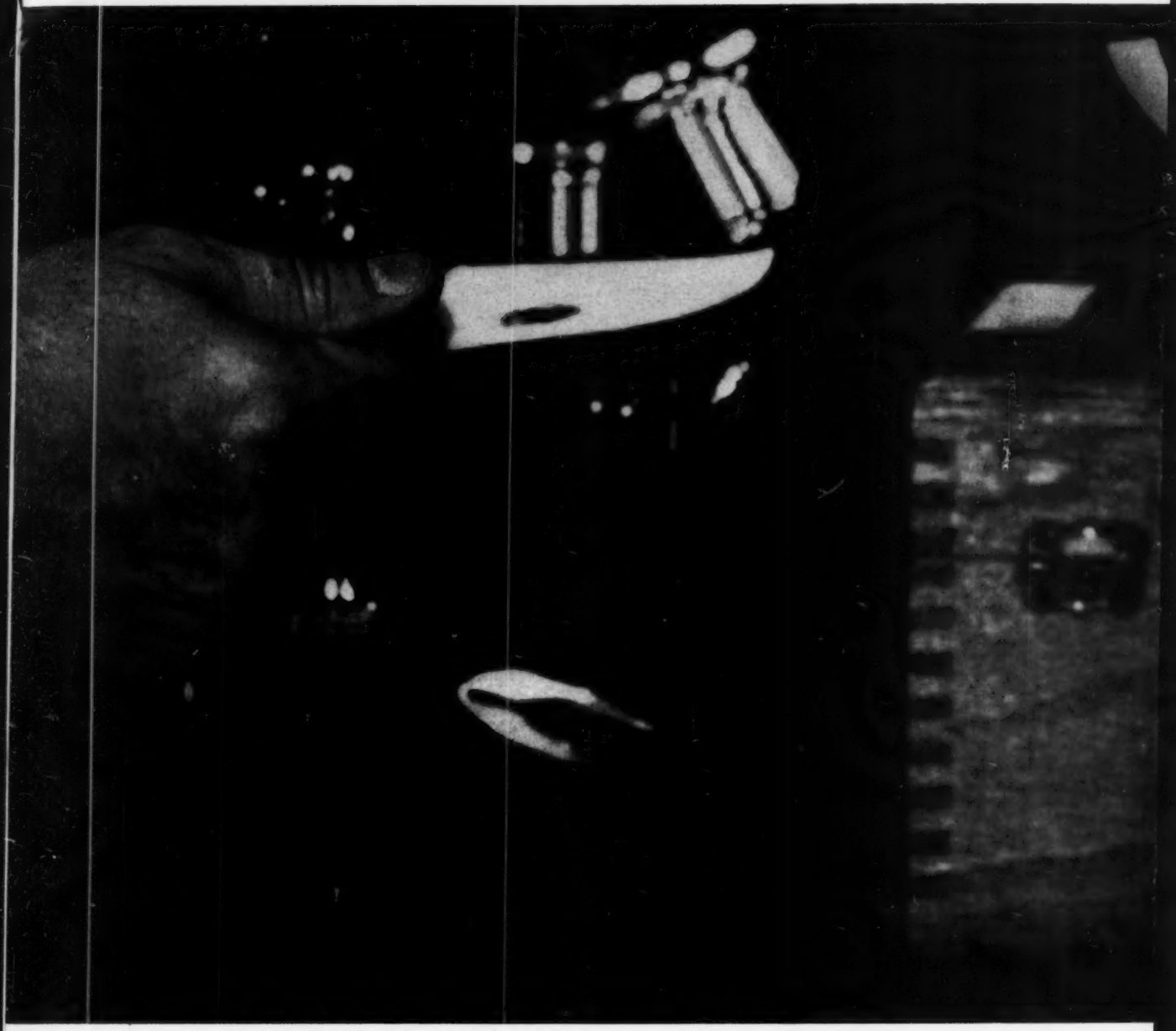
. . . A technological advance spells extra profits for small nonferrous foundries, page 34.

. . . A sales engineering program that really works for Superior Steel & Malleable Co., page 38.

Incidentally, MODERN CASTINGS has again received a NATIONAL SAFETY COUNCIL award for its crusading on behalf of plant accident prevention. This is the sixth time in recent years this award has been won. In this period, *only* MODERN CASTINGS has received this award in its category—a tribute to the dynamic and progressive outlook of the publication you read.

Harold E Green

coke...tested and retested... to give you better melting in your cupola



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Circle No. 124, Pages 129-130

Looking at Business with Modern Castings

July is not usually a good month in which to assess business conditions. You either do it before or after. Too many obscure situations have to be evaluated otherwise. Many metalcasting plants shut down for traditional vacation periods. The automobile industry, on which metalcasters depend in large measure, shuts down for model changeovers. This muddies both employment and production considerations.

As this column is being written, we are approaching an unusual circumstance in the automobile industry. Detroit has entered its model changeover period earlier than usual. Steel orders seem to presage better times ahead. Working hours are continuing to lengthen—now more than 40 hours a week.

MC SURVEY

And now comes a MODERN CASTINGS trends survey which contains some data worth considering seriously.

First, because the survey represents the secret opinions of grass roots "influentials" of AFS—Chapter leaders.

Second, because all geographical regions of metalcasting are represented in terms of numerical proportion.

Ninety-one local-level leaders were polled. They answered many questions about operations, buying intentions, and market conditions. MODERN CASTINGS' special polling machine was used.

To provide a comparison with the first annual Chapter Officers Trends Survey made last year, many of the same questions were asked.

Net result: a decidedly more optimistic outlook was recorded.

Three key facts stood out:

1. Estimates about increases in business are moderate.
2. Buying intentions revealed a "sell me" attitude.
3. Metalcasters are fighting harder for business against competitors. Indications are that they are making substantial gains.

TRENDS

36 per cent of those polled say business should be good the last half of 1961, and 58 per cent believe it will be fair. Contrast this with 21 per cent who declared it would be good the last half of 1960, and 55 per cent more who thought it would be fair.

Here's a clear indication of more optimism than prevailed at the same time last year.

Next year, 1962, looks good to 57 per cent now, as against almost 27 per cent for the comparable period a year ago.

Significantly, those who expect their plants to expand in metalcasting capacity in the next five years racked up that same percentage as reported last year—54 per cent.

Metalcasters are displaying much more competitive muscle than this time 12 months ago. Some 73.5 per cent of AFS-CO "influentials" report their plants have taken business away from

other methods of metal fabrication. Compare this with 46 per cent of the same type of group a year ago!

Conversely, only 35 per cent report losing business in the last year to other methods of fabrication. In 1960, this figure was 42 per cent.

CREATIVE SELLING

More than 80 per cent of this year's group are helping their customers to design or redesign parts so they are better suited to castings. Some 73 per cent make special efforts to sell the value of metal castings to product designers of customers and prospects.

Key reason: a step-up in effort. 84 per cent report they are making more effort along this line as compared to last year.

Hand-in-hand with this special selling effort is more quality control and research. 75 per cent reveal that their companies are now putting more emphasis on quality control than they did last year; 63 per cent more on research.

Here is an indication of the quality of AFS leadership found today at the grass roots level:

—86 per cent have a voice in the purchase of metalcasting equipment. (The figure was 82 per cent last year.)

—94 per cent indicate their companies intend to purchase metalcasting equipment in the next 12 months. (The figure was 68 per cent last year.)

Of those reporting intentions to buy, here's some interesting data.

28 per cent—melting equipment
47 per cent—molding equipment
37 per cent—materials handling equipment
24 per cent—cleaning room equipment
14 per cent—inspection equipment
23 per cent—laboratory equipment

74 per cent anticipate plant modernization in the next 5 years. This time last year the figure was 62.6 per cent.

Taken as a whole, this data represents only the thinking of those AFS-CO "influentials" who participated in MODERN CASTINGS' second annual grass roots survey.

The one point to be used as a frame of reference is that these people are influential—and they are leaders on the local level.

NPA FORECAST

You might give careful attention to the recent predictions of the National Planning Association. A non-partisan research group specializing in long term projections for business, labor, and agriculture, it reports that each worker will produce more with less plant and less equipment.

To an industry just beginning to focus on the problems of mechanization and automation, this forecast holds more than the usual significance.

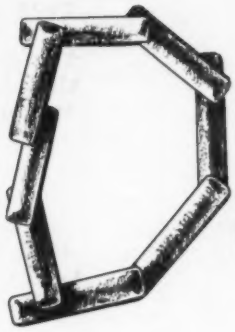
Says NPA: the value of plant and equipment per worker will increase 22 per cent through 1972, his productivity 46 per cent.

Considerable emphasis is to be put on the contributions of new technology—in electronics, chemistry, metallurgy, power.

The point: new technology is to substitute for both labor and capital equipment.

ORDERS

Improving in steel. Orders for durable goods reflect a healthy and more favorable situation than in recent months. New business is up. Defense orders are up. Machinery makers are anticipating an increase in orders the last half of 1961, especially in the fourth quarter.



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Circle No. 125, Pages 129-130

Around the World with Modern Castings

RUSSIA

Carbon steel can be desulphurized and at the same time have plasticity and ductility improved as result of recent work in Moscow. Procedure involves addition of 0.2-0.3 per cent cerium in form of 94% Fe-Ce. Care must be taken to avoid a residual of more than 0.1 per cent cerium in the castings.

Chill casting of iron is being used successfully on a variety of shapes including housings for gear pumps and filters, hydraulic panels, vessels, cylinders, piston rings, and rotary pumps. Castings weigh from 0.2 to 187 pounds and have wall thicknesses ranging from 7/64 to 8 inches. Chills last for 1000 castings if given proper care such as sand blasting, pre-heating to 390 F, ceramic washing, and smoking with acetylene flame. Success is due in part to quick shake-out while castings are at 1650-1750 F. They are placed immediately in pit for self-annealing. Speedy shakeout permits production of thin-walled castings without brittle cementite forming. Chill casting has reduced rejects from 9 per cent down to 4 per cent.

Liquid metal compression opens new frontiers for shaping metals. This unorthodox technique is a combination of die casting and hot drop forging. Aluminum is introduced into a die heated to 200 C. Metal is put into compression by dropping or driving a plunger or punch into the molten mass after it fills die but before metal solidifies. Good quality parts are claimed to have been made. Although not specified, the process would have to improve soundness and strength to justify the additional complication of mechanical compression.

SWEDEN

The world's most modern foundry for producing boiler section castings recently became operational at the Norrahammar Works near Jonkoping. The automated push button foundry uses only 8-11 employees where 50 were formerly required. Productivity has increased ten-fold to 950 tons per year per worker. One diaphragm molding machine handles the molding—660 to 800 copes and drags per shift. Two service men are responsible for operation and control of the plant. The $900,000 modernization has effected higher quality castings with finer tolerances and less scrap.

ITALY

Want to do business in Italy? A special booklet has been prepared covering: 1) The Climate for Foreign Investments in Italy; 2) Italy: Its Economy, Balance of Payments and Banking System; 3) Taxation in Italy. Write Italian Embassy, 2401 15th St., N.W., Washington 9, D.C. for complimentary copy.

CZECHOSLOVAKIA

According to a report from the Powder Metallurgy Research Institute in Prague, the cermet, Al_2O_3-Mo, is a material well suited for making protection tubes for immersion pyrometers. Superior to currently used expensive quartz tubes, this cermet withstands severe

Continued on page 14

MAGNESIUM

HINES "POP-OFF"® FLASKS

UP TO 25% LIGHTER!

STRONGER, *too!*

SIZES AVAILABLE IN MAGNESIUM:
10" x 12" through 24" x 24"

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The many inherent advantages offered by HINES "POP-OFF" flasks are augmented by their fabrication in magnesium! The lighter weight will be appreciated by your molders. The extra strength will give you even more accurate production and lower maintenance costs. And, as always, HINES QUALITY will insure a higher percentage of perfect molds.

Here, then, is the ultimate in flask efficiency! If you're planning to improve mold production, be sure to investigate HINES *magnesium* "POP-OFF" flasks. A letter, wire or phone call will bring additional information and prices.

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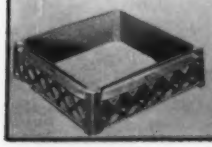
Used with HINES "POP-OFF" flasks, they'll provide economical, quantity production.

Less investment!

No stacks of tight flasks taking up valuable space!

Lower shake-out costs!



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FLASK COMPANY

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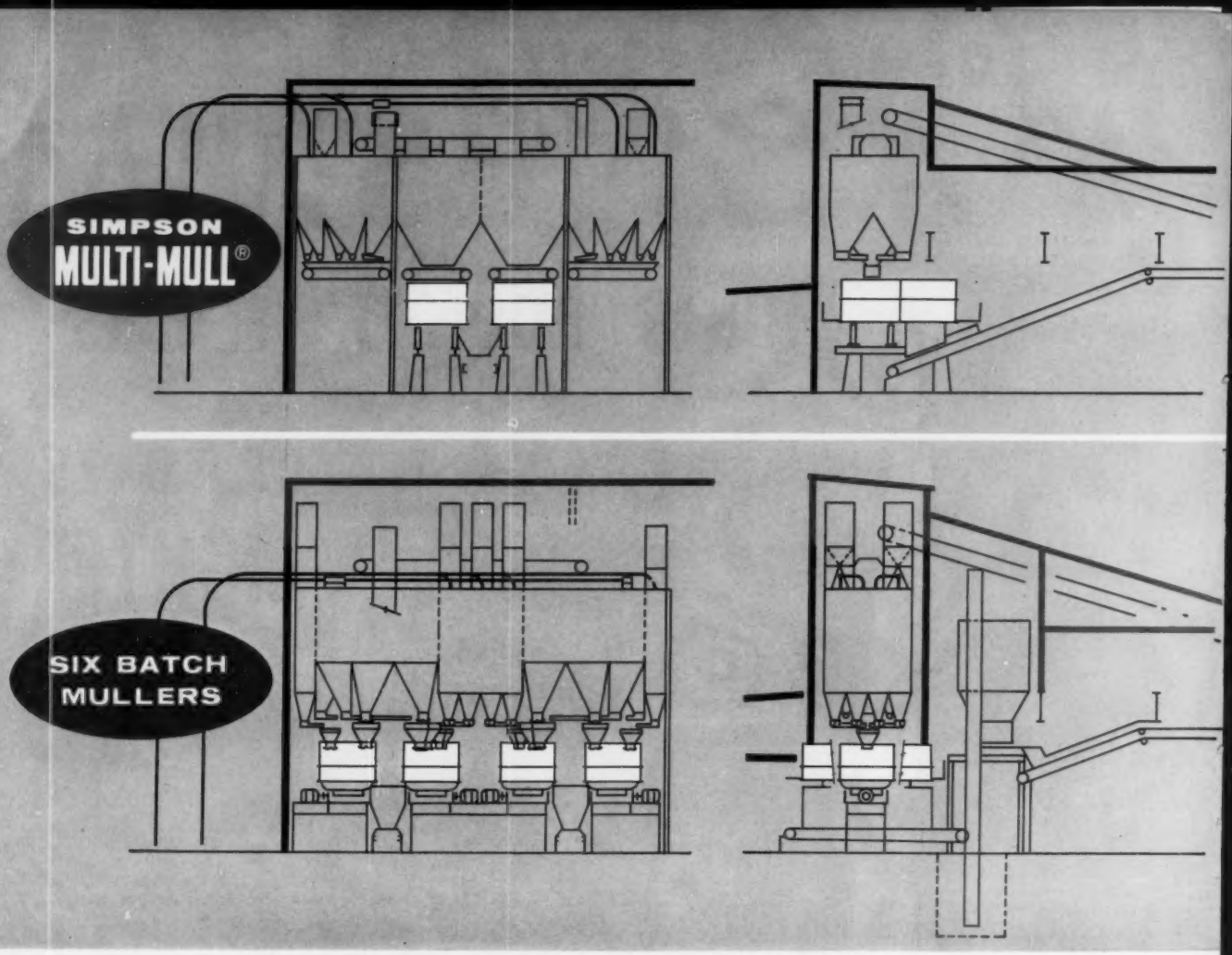
IF IT'S A "POP-OFF"... IT'S HINES... IF IT'S HINES... IT'S THE BEST

Circle No. 126, Pages 129-130



BUT, WHAT DOES CONTINUOUS

Actual cost comparison shows 50% less in capital investment per ton/per hour of prepared sand capacity

Installations throughout the country now demonstrate that the continuous Simpson Multi-Mull turns out sand having physical properties superior to those produced in any batch muller—and in the massive tonnages required for automated molding.

But how do the equipment costs compare to those required for batch systems?

The drawings and specifications shown here detail, by cost and number, the equipment components needed for a continuous Multi-Mull system and those required for a six-muller batch system—to meet the customer specifications for an automatic molding line, as outlined at right.

Fewer components = 35% less cost

Cost analysis (see table) revealed that equipment requirements for the Multi-Mull system ran 35% less than those for the batch system. Cost of the mixers alone was $17,900 less than for the 6 high-RPM batch machines. Examination of the plans above will indicate that an even greater cost differential would have existed if building alterations necessary for the batch system had been included.

Needless to say, the Multi-Mull system was purchased for this plant.

An isolated case? No. This is but one of numerous Multi-Mull installations.

What does this mean to you?

It means that a Multi-Mull sand preparing system will not only cost you less to operate and maintain—it will cost you less to purchase, less to install—and turn out more sand per dollar invested than any equipment you can buy.

... Foundrymen who are competitively waging the battle of profit vs. cost are meeting the challenge with Simpson Multi-Mull.

F861-S

NATIONAL ENGINEERING COMPANY

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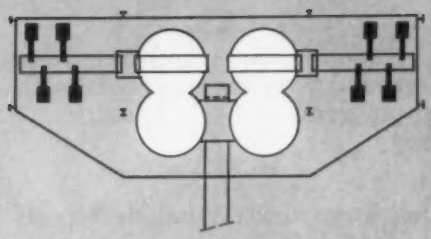
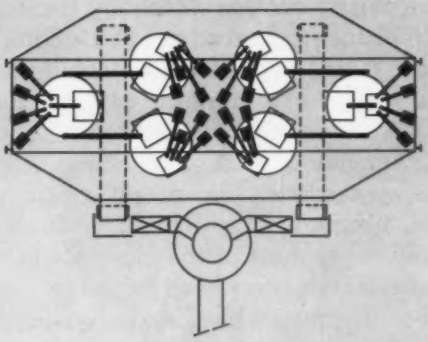
Circle No. 127, Pages 129-130



BUILDING ADDITIONS

EXISTING BUILDING



MULLING COST?

CUSTOMER REQUIREMENTS:

Sand Preparing System for automatic molding

SAND PLANT	• minimum of 228 tons per hour grey iron system sand for instantaneous supply on demand from automatic molding machines. • 17 psi (max.) green compression strength. • plus or minus .2 percent moisture control.
ADDITIVES	• four additives plus new make-up sand. • water, sand and additives to be automatically metered to muller. • additives to be stored overhead in sufficient quantity to serve 16 hours of continuous operation without recharge of bins. • a dust-tight system for conveyance of additives and sand to bins from ground level storage.
SAND STORAGE	• sufficient to empty entire distribution system at end of second shift.
BUILDING ALTERATIONS	• pits and building changes are to be kept to a minimum.

Write for Multi-Mull Bulletin

COMPARISON TABLE:

Sand Preparing Equipment Inventory

CONTINUOUS SYSTEM	BATCH SYSTEM
MIXERS*	
2-23F Simpson Multi-Mulls, 300 tons per hour capacity, dust hoods equipped with inlet chutes.	6-high-RPM batch mullers, 230 tons per hour capacity, dust hoods equipped to accommodate batch hoppers and bond weigh hoppers.
BINS	
2-for shakeout sand (60 tons ea.), 2 single tapered bottoms. 8-additive bins, 8 tapered bottoms. 2-new sand bins, 2 tapered bottoms.	2-for shakeout sand (60 tons ea.), 6 tapered bottoms. 17-additive bins, 24 tapered bottoms. 2-new sand bins, 6 tapered bottoms.
FEEDERS	
8-additive feeders, one size. 2-new sand feeders, one size. 2-sand feed belts. 2-additive feed belts.	24-addtiive feeders, in 3 sizes. 6-new sand feeders, in 2 sizes. 6-batch hoppers. 6-additive weigh hoppers with scales and controls.
AIR CONVEYOR	
1-new sand air conveyor line with diversion valve and end receiver. 2-additive air conveyor lines with 14 pneumatic valves.	1-new sand air conveyor line with diversion valve and end receiver. 2-additive air conveyor lines with 27 pneumatic valves.
DUST COLLECTOR	
4-additive bin collectors. 4-flop chutes.	9-additive bin collectors. 8-flop chutes.
MULLER CONTROL	
2-continuous moisture controllers. 6-sequence timers.	6-batch moisture controllers. 37-sequence timers and solenoids.
DISCHARGE	
1-prepared sand belt receiving hopper under discharge openings of 23Fs.	2-mill hoppers (each serve 3 mixers). 2-mill belts. 2-bucket elevators. 1-20 ton capacity prepared sand surge hopper with table feeder.
OTHER ELECTRICAL	
18-starters of various sizes. 4-110 volt feeds for new sand feeders and moisture control. 45-air conveyor controls.	44-starters of various sizes. 12-110 volt feeds for moisture and cycle control and sequence timers. 85-air conveyor controls.

RELATIVE COST

With 30% more sand capacity than specification requirements, the Simpson Multi-Mull system cost 35 % less than the high-RPM batch system.

*Capacity of all mixing equipment included or considered in this specification was based on customer experience with mullers of both types now serving automatic molding lines in this foundry.

Continued from page 10

thermal shock and molten metal erosion in cupolas, electric furnaces, ladles and pouring streams. A material with these properties should be a big help to quality control programs in U. S. foundries.

FRANCE

The Centre Technique des Industries de la Fonderie reports the benefits of injecting calcium cyanamide with nitrogen into molten cast iron. Sound castings with improved mechanical properties result. Brittleness of high silicon irons is also reduced by this treatment. Introduction of nitrogen into iron apparently affects the growth of eutectic cells.

ENGLAND

Cast iron properties are being raised another notch by purifying melts to remove deleterious trace elements. Latest research efforts by the International Nickel Co. Ltd. reveal a purification technique in which oxygen is blown across the surface of a vibrating cast iron bath. The process is successful in removing or reducing antimony, boron, calcium, chromium, gallium, germanium, lead, manganese, molybdenum, niobium, phosphorous, potassium, silicon, silver, sodium, sulphur, tellurium, tin, titanium, tungsten, vanadium, zinc and zirconium. Vibration speeds the removal of most of the elements in cast iron. By eliminating these elements, metalcasters have far better metallurgical control of the structures in gray, white, and ductile iron.

Pressure drying—a new approach to mold drying on the foundry floor can save foundries time and dollars. Marked improvement in drying efficiency has been proven with a system that blows hot air into mold at a pressure of 24-in. w. g. All riser and sprue openings are closed off with plates so the air has to work its way out of the mold through the interstices between the sand grains, and from the inside out. As a result, compared with conventional low pressure drying, mold drying takes only one-fifth to one-third of the time and consumed only one-fifth to one-third of the energy!

EUROPE

Production of 12,200,000 tons of castings was announced as the 1959 output of the eleven countries belonging to the European Committee of Foundry Associations. Some 625,000 persons are employed in metalcasting plants located in these 11 countries—Austria, Belgium, Denmark, France, Germany, Great Britain, Italy, Luxembourg, Netherlands, Spain, and Switzerland. The European Committee has 11 active sub-committees working on Training, Productivity, Time Study, Internal Organization of Foundries, International Quality Labels, Costing, Customer Collaboration—Market Research and Development, Standardization of Conditions of Sale, Work Safety, Raw Materials and Energy, and European Institutions. An attractive tri-lingual (English, French, German) brochure has been prepared to explain the purposes and activities of the European Committee of Foundry Associations. Copies may be obtained by writing The Joint Iron Council, 14, Pall Mall, London, S. W. 1.

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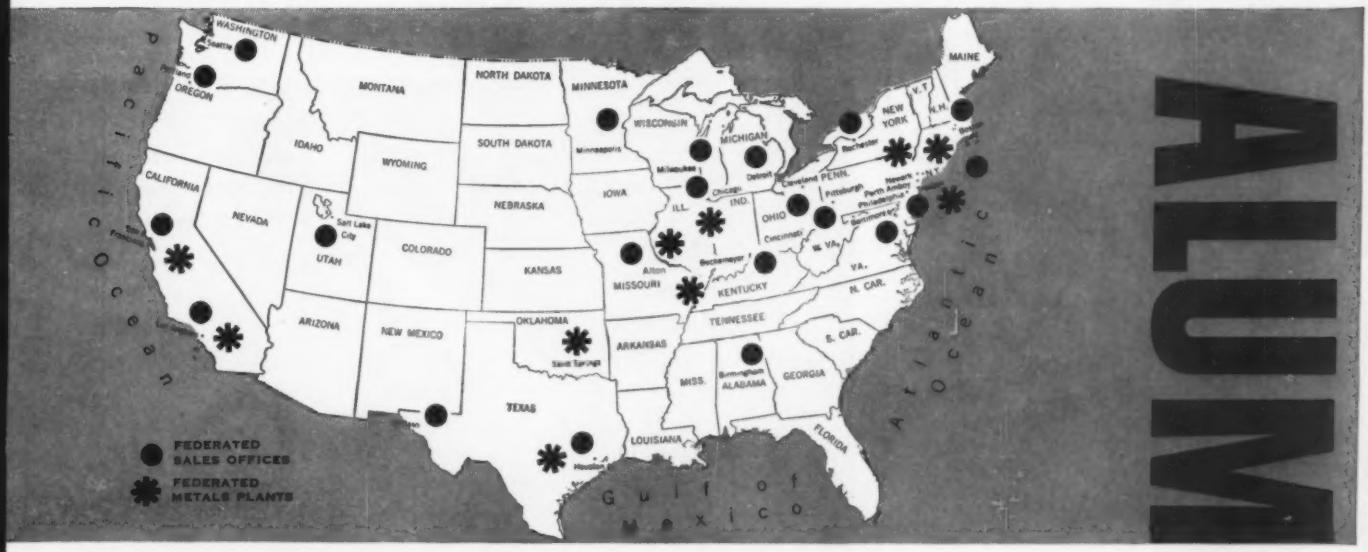

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REVERE ALUMINUM

Circle No. 128, Pages 129-130

From and For the Reader . . .

APPROACHING 500,000 PSI

Our International Nickel Bayonne (N. J.) Research Laboratory has developed a revolutionary new 18 per cent nickel alloy steel which can provide a yield strength in excess of 250,000 psi while maintaining a nil ductility temperature below minus 80 F. Another characteristic is a notched tensile strength which exceeds 400,000 psi.

The new steel has a nominal composition of 18 per cent nickel, 7 per cent cobalt, 5 per cent molybdenum, less than 0.50 per cent titanium and a maximum of 0.05 per cent carbon. By modification of composition, there are indications that high strength levels of up to 500,000 psi, or even higher, may be achieved.

The development points the way for a new family of high-strength "Mar-aged" steels with advanced engineering design possibilities for civilian and defense applications involving exceptionally high pressure and stress.

We are currently working on a casting version of this material and think we may be about two months from pinning down a preferred composition range. We then hope to take this information to some interested foundries for evaluation and possible exploitation.

Castability and properties after heat treatment seem to us to be quite promising and we expect ultimately to have something of definite interest in this area.

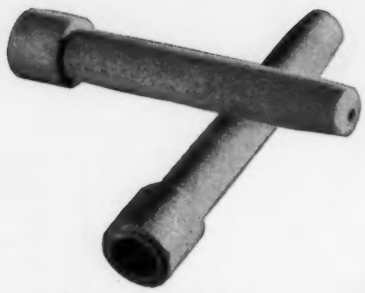
R. J. Raudebaugh
Supervisor
Iron-Nickel Alloys
The International Nickel Co,. Inc.

TIN IN CAST IRON

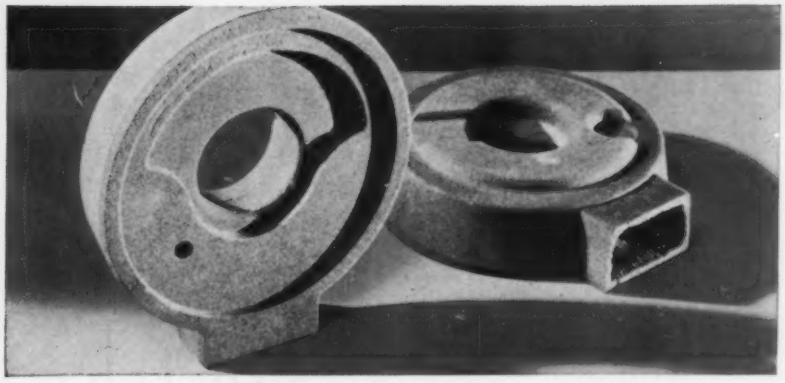
I always look with interest for the next copy of MODERN CASTINGS of which I am an avid reader. In the May issue, the series of articles devoted to metalcasting trends in the foundry market analysis and the top technological "breakthroughs" for 1961 are particularly interesting, even to the European foundryman.

May I complete the information appearing in "Around the World", page 9, covering the study by the B.C.—I.R.A. and the Tin Research Institute about the influence of tin on cast iron?

As a matter of fact, the results of



Shell cores start a chain reaction and lop 50% off core costs



Read how cores like these bonded with Durez resin are setting new records for economy at Auto Specialties Co. (Canada) Limited.

They weigh much less, so they're easier to handle. They use less sand.

But that's only the start of snowballing savings this foundry makes with shell cores—cores bonded with Durez foundry resins.

On one casting, for instance—an automotive differential housing—dimensions are so accurate now with shell cores that gauging has been eliminated. A tube core fits the body core so snugly that flash no longer forms on the inside of the casting. As a result, foundrymen have been able to forget about a previously needed air-hammer chipping operation.

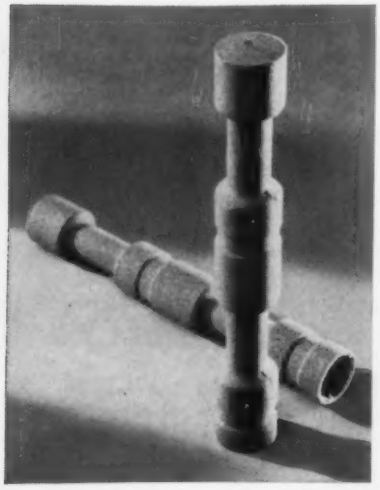
Altogether, savings come to just about *half* the previous core cost. And the foundry is chalking up similar records on many other jobs.

Fewer cores needed. Multiple stick cores now replace single cores to save setting time. One casting, formerly made with four oil-sand cores, requires only two shell cores.

What's more, the shell cores don't

have to be dried. When finished, they're sturdy enough to stack without breaking. Because less storage space is needed, it's much simpler now to maintain a backlog of cores for filling rush orders.

Is it any wonder that, after producing 70,000-plus shell cores, men of this foundry are sold on the process more solidly than ever?



What you can do about this. One good way to explore shell-core economies for your foundry is to call in your Durez technical service man. He has helped many foundries convert to this process, so can give you answers based on practical experience. He can show you how to minimize shell-core and shell-molding problems with the consistent day-to-day and month-to-month results Durez foundry resins give you. Have a talk with him soon.

Here's the latest on shell molding—authoritative, up-to-the-minute data on patterns, materials, mixing, temperatures, lubricants, molds, cores. It's the 36-page *"Durez Guide to Shell Molding"* that can help you evaluate the process for your foundry. Write for your free copy today.

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HOOKER CHEMICALS PLASTICS

Circle No. 129, Pages 129-130

these investigations are rather a confirmation than an information, and we point out that Belgian research workers were the first to define exactly the effects of copper and tin in cast iron.

In 1954 at the International Foundry Congress in Florence, Italy, Professor A. De Sy read a paper entitled "Mechanism of gray iron ferritization and study of its rates decrease by tin and copper." This paper summarizes the results of original investigations carried out at the Belgian Foundry Research Centre of Ghent by Prof. DeSy and MM. J. Vidts and J. Van Eeghem.

The conclusions of the final report indicate the importance of the "slow down" action of copper and tin on the reactions of direct and indirect ferritization of cast iron.

Appreciable amounts of free ferrite are suppressed by small additions of tin (some hundredths per cent). As to this, it is best to be prudent because larger additions of Sn increase the brittleness of cast iron.

The paper appeared in the December, 1954 issue of *La Fonderie Belge*. The American investigations carried on at the Battelle Memorial Institute for the Tin Research Institute refer to the original results achieved in Belgium.

A. Pirson
Secretary
La Fonderie Belge
Brussels

Editor's Note: It is hoped that credit has been given where credit is due.

OBJECTION FROM M.I.T.

It seems to me the answer given to the enquiry of "G. S." under the heading "Meeting Specifications" (April Letters column, page 18) is incomplete and in some ways incorrect.

Mil. Spec. C 21180 A(ASG) was written specifically and primarily to cover high quality sand castings made by the techniques of careful quality control over gases and alloying elements, and using chills and risers judiciously to insure soundness according to the techniques developed at M. I. T. over the last several years and published in detail in AFS Journals and Transactions.

This Spec. was made inclusive enough at the time to cover permanent mold castings, etc., but the mere fact of pouring aluminum into a permanent mold doesn't automatically insure meeting the Specs; the same general order of engineering care must be taken as for sand castings in order to achieve the premium quality indicated.

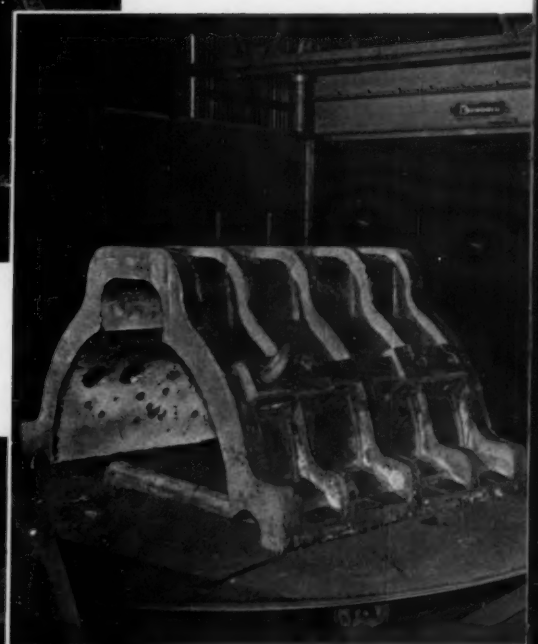
Continued on page 20

here's PROOF of

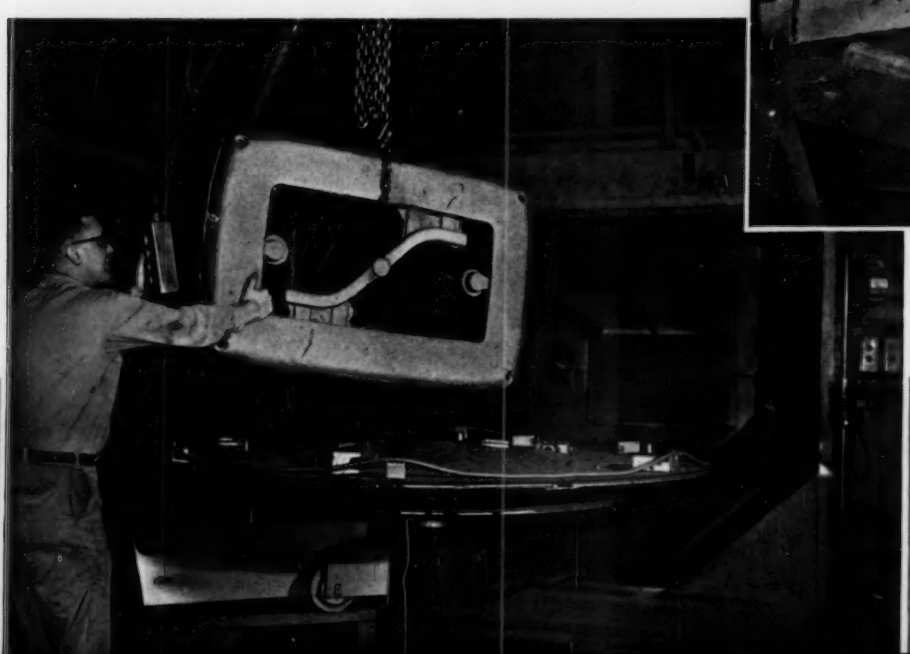
PHOTOS AND STATEMENT FROM

Ingot mold flask (for steel mill use) weighing 18,500 lbs., being inspected by Metal Blast's abrasive engineer, *prior* to blast cleaning with "SUPER-STEEL" shot.

The W. S. Hodge Foundry has been in continuous operation for 85 years — serving the industry with highest quality gray and ductile iron castings since 1876.



Ingot mold flask weighing 11,300 lbs., *after* cleaning with "SUPER-STEEL" shot.



Ingot mold hot top cover, 493 lbs., *after* cleaning with "SUPER-STEEL" shot.

"SUPER-STEEL" performance!

SHOT OR GRIT

THE W. S. HODGE FOUNDRY, GREENVILLE, PENNA.

The *unretouched* photos on the opposite page, taken recently in the HODGE FOUNDRY, should go a long way toward proving that "SUPER-STEEL" is doing an outstanding job of cleaning castings. For further affirmation, please read what W. S. Hodge has to say about their experience with this fine abrasive:

> ***"Metal Blast's "SUPER-STEEL" has substantially reduced costs on our blast cleaning operations over the steel shot we were previously using. We are very pleased with the cleaning and appearance of our castings and well satisfied with the abrasive engineering service provided by Metal Blast. We highly recommend "SUPER-STEEL" to all foundries interested in saving on their cleaning costs."***

If you're not entirely satisfied with the performance (or cost) of your present steel abrasives, why not try "SUPER-STEEL"? In addition to the excellent performance and service referred to above, you'll get greater "resistance to breakdown" and lower maintenance costs — yet you pay less for "SUPER-STEEL"! You can't help but cut cleaning costs — in fact, we'll guarantee it! Write, wire or phone collect — we'll rush a trial order, test sample, more information or have our abrasive engineer call

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Circle No. 130, Pages 129-130

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Whatever size of PAYLOADER tractor-shovel you need, you can be sure it is designed with this same attention to production insurance. Your Hough Distributor will gladly show you how these high-production and low-maintenance features can "ease the profit squeeze" of your bulk handling.

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Circle No. 131, Pages 129-130

Continued from page 17

Furthermore, the properties covered by the specifications can be guaranteed at strategic areas "in the casting" and not weaseled out of separately cast coupons.

Howard F. Taylor
Professor of Metallurgy
Massachusetts Institute of Technology

Editor's Note: We thank Professor Taylor for correcting a "too short" reply and filling in the important details concerning this Spec.

EDUCATIONAL FOUNDRY

We are in the process of constructing a new educational foundry. We have left an opening in the floor for pouring which is 18 feet square and approximately 30 inches deep. We plan to pour mainly non-ferrous metal but would hope to expand to ferrous work in the future.

These are the questions that this pouring area present:

1. Most of the foundries in this area do all of their pouring on a concrete floor. Is this now considered a safe practice? I would prefer this from the standpoint of keeping the shop clean.
2. If a sand floor is still recommended, what would you suggest for fill in this opening which is 30 inches deep?
3. Would a two-inch recessed concrete floor with a two-inch thickness of sand over the top be recommended?

Wesley L. Face
Foundry Instructor
Stout State College
Menomonie, Wis.

Editor's Note: In consideration of the three proposals, we are of the consensus that No. 3 would be the best application for your laboratory. However, it might be well to make this recessed concrete floor three inches deep rather than two inches. This will allow for approximately two inches of sand with a one-inch retaining wall to prevent sand spreading all over the foundry floor.

We concur with the use of a cement floor for the pouring area in regard to housekeeping benefits, but molten metal, when in contact with moist concrete, creates a very unsafe condition. When spilled on cement floors, it can cause minor explosions, damaging the floor and creating hazardous operating conditions. We suggest you investigate the possibilities of a special, heat-resistant cement which is said to be available now.

Continued on page 22

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1 Technology—many million dollars a year, invested in UCM's 600-man research and development center—helps you produce better, more profitable metals. This is one of the 5 intangible but ever-present extra values of Union Carbide Metals' FIVE-DEEP alloys.

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4 Unmatched Facilities free you from delivery worries. Only UCM gives you 6 plants—3 with their own power facilities—and 17 warehouses, all located for fast shipments by rail, truck, or water.

5 Strictest Quality Control—with over 100,000 tests per month from mines to shipment—makes sure you always get alloys of uniform size and analysis, with minimum fines, lot after lot.

For better metals, production economies, bigger profits, insist on UCM's FIVE-DEEP alloys. Union Carbide Metals Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y., producer of "Electromet" brand metallurgical products.

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With an arrow's speed and aim,
Junior takes his pigs to market
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Circle No. 133, Pages 129-130

Continued from page 20

FEDERAL SPECIFICATION

Proposed Federal specifications are being prepared covering copper-base alloy cast bar. Comments are being solicited on this proposal. This is a part of the series of specifications covering copper-base alloy castings. It will be also tied in with the standard covering the chemical and mechanical properties of copper-base casting alloys.

T. E. DUNN, JR., Assistant
Ordnance Materials Research Office
Watertown Arsenal
Watertown, Mass.

Editor's Note: We have submitted this specification to a number of well qualified people in industry and can see no particular objection to it as it is prepared. However, we wish to reiterate what we have stated previously that there appears to be an increasing number of federal and military specifications, most of which in our opinion are not justified. Instead, they only lead to complications on the part of industry when supplying items in accordance with these specifications.

For the most part well accepted and adequate specifications such as promulgated by the American Society for Testing Materials should serve the requirements of federal purchasers with the possible exception of special packaging which may be required to satisfy conditions such as the Military. S. C. Massari, AFS Technical Director.

Copies of the proposed Federal Specification for Copper-Base Alloy Cast Bar may be obtained from the Ordnance Materials Research Office, Watertown Arsenal, Watertown 72, Mass.

CONTINUING DISCUSSION

Editor's Note: In the January issue of MODERN CASTINGS, *A. G. Johnson, Quality Control Supervisor of Canada Iron Foundries, Ltd., expressed some points on an article "A New Concept for Hot Sand Properties" by Vingas and Zrimsek, from the November, 1960 issue. The authors answered Mr. Johnson in the May issue, and now in turn, they are answered.*

Every now and then a new prophet arises and demands that all our sacred cows be slaughtered and the temple destroyed. Generally, if they really buckle down to work on sand they later find a little past work that can be salvaged.

The records of many AFS papers and committee meetings show correlation between castings and test figures. What we need is more of this

mixture of inspiration and perspiration and less disparagement.

Most workers in our field know that many of our troubles are caused by expansion but seldom can correlate the two. Here is a fertile field for new thinking. We haven't yet found the right way to measure expansion.

Incidentally, Mr. A. G. Johnston's ideas on expansion may not be as far off as those quoted by his critics. The figures quoted by Zrimsek and Vingas were obviously taken from the Handbook of Chemistry & Physics. Their figure for quartz was for fused quartz. Alpha quartz is listed as 7.97×10^{-6} parallel to and 13.37×10^{-6} perpendicular to the axis. This is the one commonly used in foundries.

Mr. Johnston referred to carbon molding rather than graphite. A good figure for the expansion of a carbon being currently offered for molding is one-eighth that of silica sand. The figure quoted for concrete is actually listed as 10 to 14×10^{-6} rather than 10.14×10^{-6}. However the form of this material used in the foundry is usually cement bonded silica sand which falls into the category of high expansion and early softening of the bond to give high hot deformation.

With the wide range of castings made it is no wonder we have a wide range of control figures. In the field of strengths there is usually some safe minimum and a wide usable range above it. This does not relieve us from measuring to stay above the minimum.

When we theorize about mold materials for molten metals we must remember not only green sand but dry sand, shells, steel molds, plaster, and even rubber. We must also remember how important timing is, and how little things like exothermic reactions and leaky metal skins can confound us.

Frank S. Brewster
Director of Research
Brumley-Donaldson Co.

WELDABLE ALUMINUM BRONZE

Editor's Note: This discussion comments on the article "Weldable As-Cast Nickel Aluminum Bronze Composition and Microstructure," which appeared in the February issue, page 72.

The authors could be right about the ability for weldable aluminum bronze to tolerate .10 lead and .16 Si, and they could also be very wrong.

The study seems to indicate that certain microstructural components

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A minimum of three chemical analyses is performed on each heat of Wheelabrator Steel Shot to assure conformity to rigid chemical standards. Detailed laboratory analysis of microstructure further assures product uniformity.

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To achieve a uniform finish in blast cleaning operations, at a relatively constant and predictable cost, and at uniform production rates, the abrasive used must be of uniform hardness and quality. Wheelabrator Steel Shot gives you this uniformity, from box to box and shipment to shipment. Its hardness, chemical analysis, microstructure and density are carefully maintained by close production controls and detailed laboratory analysis. Wheelabrator Steel Shot gives you the Vital Values of uniform cleaning results, uniformly fast cleaning speeds, reduced maintenance of your blast equipment, and uniformly low cleaning costs. Get the complete story in our Handbook of Blast Cleaning Abrasive Performance.

VITAL VALUES FOR INDUSTRY

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Circle No. 134, Pages 129-130

resist cracking while others accentuate cracking. The process for controlling the desired structure is not spelled out, and until it is, the hazard remains.

The movement of lead in the structure, is not defined. Lead is rated as insoluble in the solid in most copper base compositions but it might be found to possess a limited greater solubility in one structural component as compared to another. The fundamental work of determining this solubility and its influence on "hot shortness" for example, remains to be done.

Meanwhile the circumstantial evidence of the damage to weldability of lead in copper-base alloys, remains. The evidence is supplied for nickel base alloys and Kihlgren's early work on the lead damage to cupro-nickel ductility at elevated temperatures has been repeatedly confirmed. Nickel base alloys will crack along the line of a pencil mark, if lead is a constituent of the scribe. At such a surface the lead content may be very high, in terms of % lead. For specification purposes, the base metal may be restricted to .01% and in many cases as little as .001% with the hope that the contamination will be less. In these alloys, lead is regarded as practically insoluble and minute percentages can spread themselves over the grain boundary surfaces, leading to hot cracking. Fine-grained structures, would possess a greater grain boundary surface and conceivably accommodate more lead, with less damage to weldability.

Until lead can be fixed by establishing its solubility in the several structural components or rendered harmless by agglomeration, and the methods for controlling these structures established, it would continue to be desirable to avoid the risk, by holding lead contents down to relatively harmless amounts.

James S. Vanick
Metallurgist and Consultant

HIGH RELIABILITY

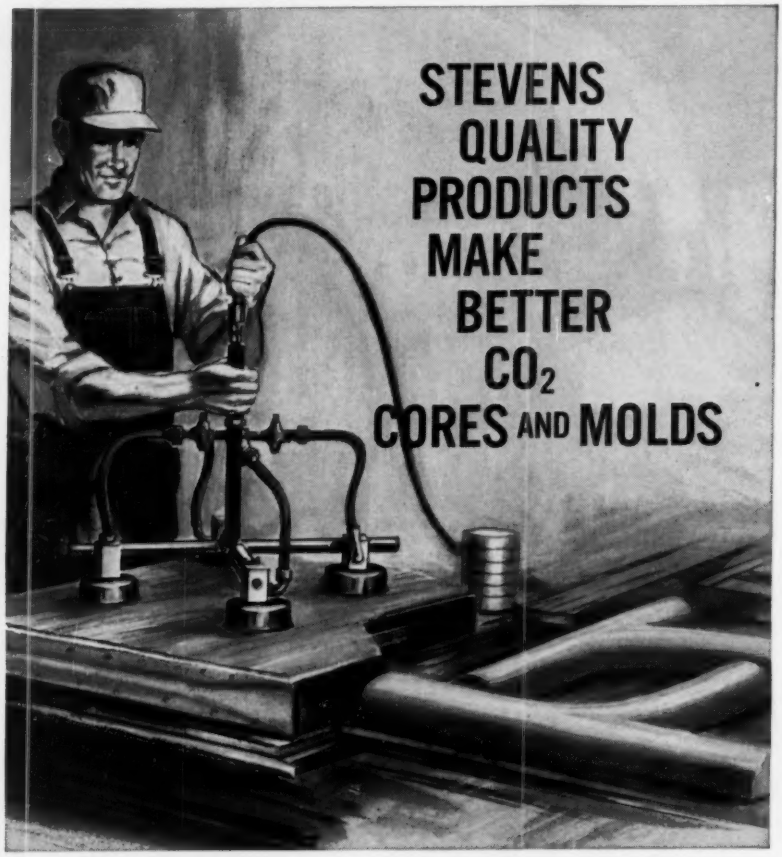
Editor's Note: This discussion centers on a Castings Congress paper, "Meeting the Challenge of High Reliability Castings," by W. Babington, E. E. Miller and W. R. Clitherow.

The team effort of Bell Telephone Laboratories and Western Electric Co. is an excellent example of what can be done by coordination of efforts between engineering design and manufacturing to assist the foundry in its efforts to expeditiously provide quality castings. Their realistic approach to quality and strength requirements is also exemplatory. We wish to congratulate them on this presentation.

Most foundrymen, I am sure, are pleased that Bell-Western Electric have recognized that the procurement of high quality castings requires dealing with foundries having the capabilities for both production and quality control. It is only good business to procure quality parts from producers of quality. It is a healthy sign to see that Bell-Western Electric are advocating sound procurement practices.

Wellman Bronze and Aluminum Co. is pleased to have passed the scrutiny of the Bell-Western Electric team, and we are producing castings meeting their requirements. We intend to improve our position by developing production, inspection, and delivery practices which are even better than those we now follow. It is only by continued improvement in these fields that a foundry can keep up with the increased requirements of this space age.

K. E. Nelson
Head, Technical Service & Develp.
The Wellman Bronze & Aluminum Co.



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Circle No. 135, Pages 129-130

Heaven Help Men— When Women Invade Foundry

by H. F. Dietrich

Someone once asked what I thought about women workers in the foundry. I promptly replied that a woman's place is in the home. Since then, I have been educated. Women have invaded every male sanctuary.

If you could call her a woman, the first female worker I saw in the foundry was by all standards an Amazon. She would have had to spot Jack Dempsey 10 pounds, and I am sure she would have won the match in three rounds. If there was anything in the coreroom where she worked that she couldn't lift, I never saw it. She asked no quarter, and gave none. No one interested in keeping his front teeth made glib remarks to her, or about her.

Being young and curious, I began to wonder what featherbrain thought up the idea that females were the weaker sex. Of course, this was back in the days when men were men—and some women were too.

During World War II, because of the shortage of manpower, women invaded the foundries in increasing numbers. Many of us responsible for production learned just how temperamental a foundry worker could be. We discovered—with the help of these prima donnas—that there were drafts under the coreroom benches, rats existed in the storage bins, Monday morning was wash day, and rough coreboxes broke long fingernails. None of these enlightening conditions had been brought to our attention before the influx of females into our formerly purely masculine domain. It is hard to imagine just what the old time sand rat would have thought had he come back to see frills and curtains in the rest rooms.

We developed female coremakers, checkers, lift truck jockies, and even managers. The laws enacted in some states to protect (?) the female employees would have insulted our original coreroom Amazon. Load limits were set at 30 pounds. As a result, we knew the weight of everything in the foundry.

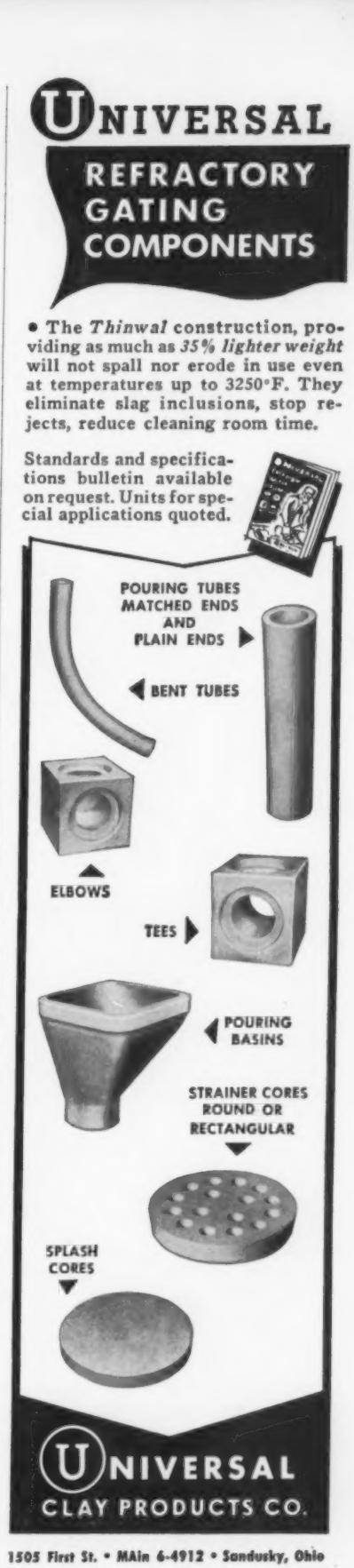
In one foundry where we employed lift truck drivers, when the transportation pilot was a woman, a man had to walk beside the truck to move things that weighed over 30 pounds. He couldn't ride! To see a man jog along beside a lift truck like a leashed Dalmatian was an insult to the human race. It was never quite clear to me why the man couldn't double as the truck jockey. The only inference that could be drawn was that a man so employed was too stupid to find the handles to operate the machine.

One thing that could account for this waste of manpower—this feather bedding that at times became more literal than figurative—was the fact that the foundry was run on the old cost-plus-10 percent basis. With this system, cost of operation was no object. The more you spent, the more you profited.

The original mold checking system in this foundry was done by consecutively numbered cards that were picked up from the pouring floor. A man working out of the production office compared the card numbers.

Then we got women checkers. They were supposed to count the molds as they slowly traveled past the checking station to the pouring floor. The original checker checked the checkers every three hours. Because of miscount, another woman was installed to verify the count. The result was a complicated system in which we had checkers, who checked the checkers, who checked the checkers.

For those of you who are contemplating for the first time, hiring of women in the foundry, allow me to give you some advice. You must prepare for a new way of life! The foundry must be hermetically sealed. Profanity will be allowed to flow only in one direction. You must be prepared to see coremakers and lift truck drivers shed tears when you explain that their work is unsatisfactory. And you will be subjected to a persistent, inexorable, excruciating coercion that would make a Chinese brainwashing seem like an ice-cream social.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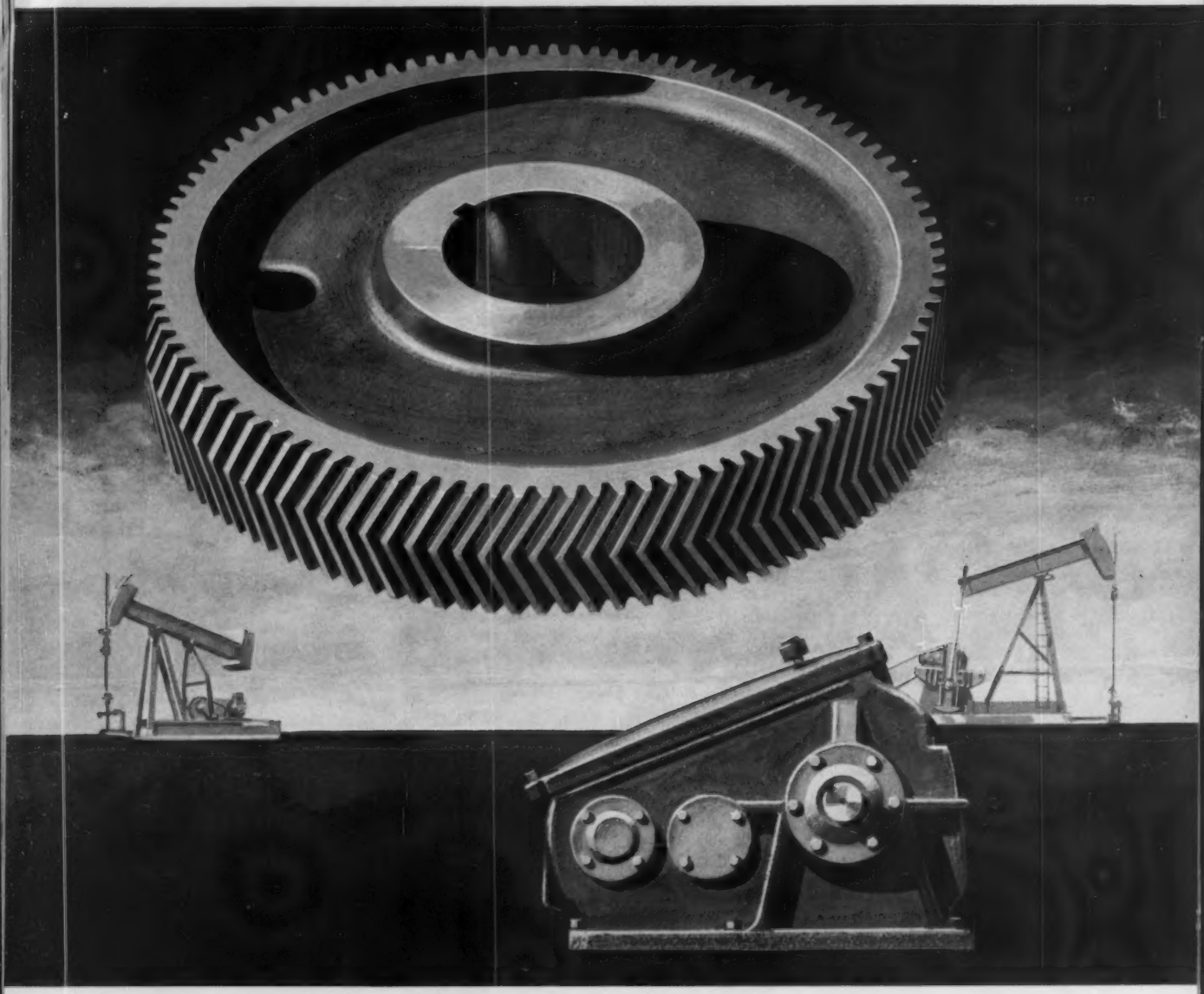
How the Foundry Industry Serves America . . . #16 of a Series



IRON CASTING REPLACES STEEL FORGING, SPEEDS PRODUCTION, CUTS COST 44%

Installed in speed reducers on oil field pumps, this high speed gear has to be strong enough to stand up under load reversal shocks every 180 degrees of gear rotation. Originally, it was produced from a steel forging and cost $77.61 to make. Now, as an iron casting, it's turned out for just $43.39!

Material cost dropped from $36.00 to $21.70 and machining time was cut from 251 to 60 minutes per gear. Estimated annual savings resulting from the change on a complete line of speed reducers—$28,300! What's more, product efficiency improved—because cast iron has its own built-in lubricant to reduce wear on gear teeth.

This is an excellent example of how modern iron castings can solve problems of industrial design and effect substantial manufacturing savings.

For the production of structurally sound iron castings, Hanna Furnace provides foundries with all regular grades of pig iron . . . foundry, malleable, Bessemer, intermediate low phosphorus, as well as Hanna Silvery.

Facts from files of Gray Iron Founders' Society, Inc.

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Circle No. 137, Pages 129-130

Good Questions Keep SH&AP Office Busy

By Herbert J. Weber

Letters and telephone calls come into AFS Headquarters in a steady stream, mostly from foundrymen seeking information, advice, or help.

Many of the questions and comments are directed to the SH&AP office—some of which are worth sharing with all safety-conscious foundrymen.

Here is a *potpourri* of subjects—from toxic materials to lightning.

Ferro-Boron, Boron—Poisonous?

Ferro-boron is used as an inoculant for nodular iron or as a grain refiner in copper alloys. Only a trace amount of boron is retained in the metal and the boron oxide given off reacts exothermically with water to form boric acid.

Usually only mild irritation of the nose and throat is experienced and the acid mist may be considered a nuisance rather than a true poison.

Another Foundry Use of Bentonite?

During wet drilling operations in a pegmatite vein of a Rumanian mine, bentonite was added to the drilling water. The pegmatite contained 89 per cent silica.

An addition of two per cent bentonite to the drilling water reduced the number of dust particles 94 per cent.

Would this have a foundry application? How about collector-dust disposal; wetting down foundry floors; would it improve the efficiency of a wet collector?

We've Been Asked About Potassium Fluoborate

We haven't been able to uncover any cases of eye irritation or dermatitis from the use of this chemical in foundry sands.

Other fluorides, such as ammonium borofluoride and ammonium acid fluoride, used as inhibitors in magnesium molding sand do decompose with the formation of fluoride-containing fumes.

There have been cases of dermatitis with these.

Furfural Will Make You Weep

Furfural used in the hot core-box technique belongs to the family of aldehydes. The maximal allowable concentration is 0.5 parts per million for an eight-hour day.

This low concentration is established to avoid smarting of the eyes—not to prevent poisoning.

In practice, the concentration sufficient to produce poisoning could not be tolerated by man—the atmosphere being unendurable.

The vapors may therefore be regarded as a nuisance which if great enough would need to be controlled by exhaust ventilation.

Nickel Carbonyl—Very Poisonous!

Nickel carbonyl is used in the pattern making trade to deposit a coating of pure nickel on a pattern.

This chemical is not only very poisonous but it is also flammable. Its vapor is explosive. When plating patterns, maximum security procedures must be used (see Modern Castings, Aug. 1960). The allowable concentration in air is one part per billion —a mere trace.

Is Your Foundry Protected Against Lightning?

Last year lightning struck a plant in Indiana resulting in a $750,000 property loss. Moreover, the plant lost six months production time.

If you're not sure whether or not your foundry is protected, better write to the Lightning Protection Institute, 53 West Jackson Blvd., Chicago 4, Illinois, and ask for its free booklet "Lightning Facts and Figures."

How About Manganese Poisoning From Making Manganese Steel?

The maximal allowable atmospheric concentration of manganese is six milligrams per cubic meter. I have never encountered concentrations in excess of this in the foundry industry and have not heard of a case of manganese poisoning in foundrymen.

Cast Metals' Vital Role In Industrial Arts

By R. E. Betterley

Industrial Arts, as used by educators today, encompasses school work where study is concentrated on industrial materials, tools, equipment, processes, and occupations.

Industrial Arts shops may be "unit" (teaching on subject, e.g. machine shop or foundry) or "general" where several areas, using various materials, are taught. In some cases a "general" shop may be limited to one general field such as a "general metal shop."

The objectives of Industrial Arts programs vary, depending upon the grade-level being taught. Leaders in the field have, nevertheless, long realized the exploratory and general education goals of the programs should be reached by means other than *simply teaching manipulative skills* in the use of industrial tools and materials.

Recently, Industrial Arts leaders attending a U. S. Office of Education Workshop Conference on "Positive Approaches to Issues in Industrial Arts," selected these broad objectives:

1. To develop in each student an insight and understanding of industry and its place in our culture.
2. To discover and develop talents of students in the technical fields and applied sciences.
3. To develop technical problem-solving skills related to materials and processes.
4. To develop in each student a measure of skill in the use of common tools and machines.

What about cast metals in the secondary school's Industrial Arts program? For my money, this area of instruction can significantly contribute to the above objectives for the following reasons:

1. *Cast metals is a prominent basic industry*—an industry with a $6½ billion national product. Castings are used directly or indirectly in practically all manufactured articles.

2. *It encompasses a broad range of subject matter contributing to general education goals.* The applied arts and sciences, humanities, communications and all broad areas of education are involved. Casting knowledge adds to consumer knowledge. It provides another opportunity for the student to learn *about* industry. He experiences creativity by converting raw materials to new and different forms—forms having greater use and value.

3. *Cast metals is challenging, interesting and intriguing.* The student is *easily motivated* by the process of melting metal and having it solidify in a mold to a desired shape—created by his own skill. Show me an experienced foundryman, old or young, who is not fascinated by the flow of molten metal.

4. *It introduces and teaches salable skills.* These can be developed and utilized by the non-college student.

5. *Secondary-school foundry can be taught with a minimum of equipment, tools and materials.* This is practical for small schools where it should be taught as an "area" of a "general metal shop".

6. *It involves problem-solving situations.* No one knows this better than a foundryman. Yet, the student, with capable teaching, can experience "quick success," (a very important point in any educational endeavor).

7. *It produces functional products, involving many operations,* as opposed to the "exercise" method of teaching operations by repetition.

8. *Contributes to the practical training of the college-bound engineering student.* As you know, such training is either lacking or de-emphasized in engineering curricula.

This discussion does not exhaust the area of cast metals instruction, therefore the subject will be expanded next month.

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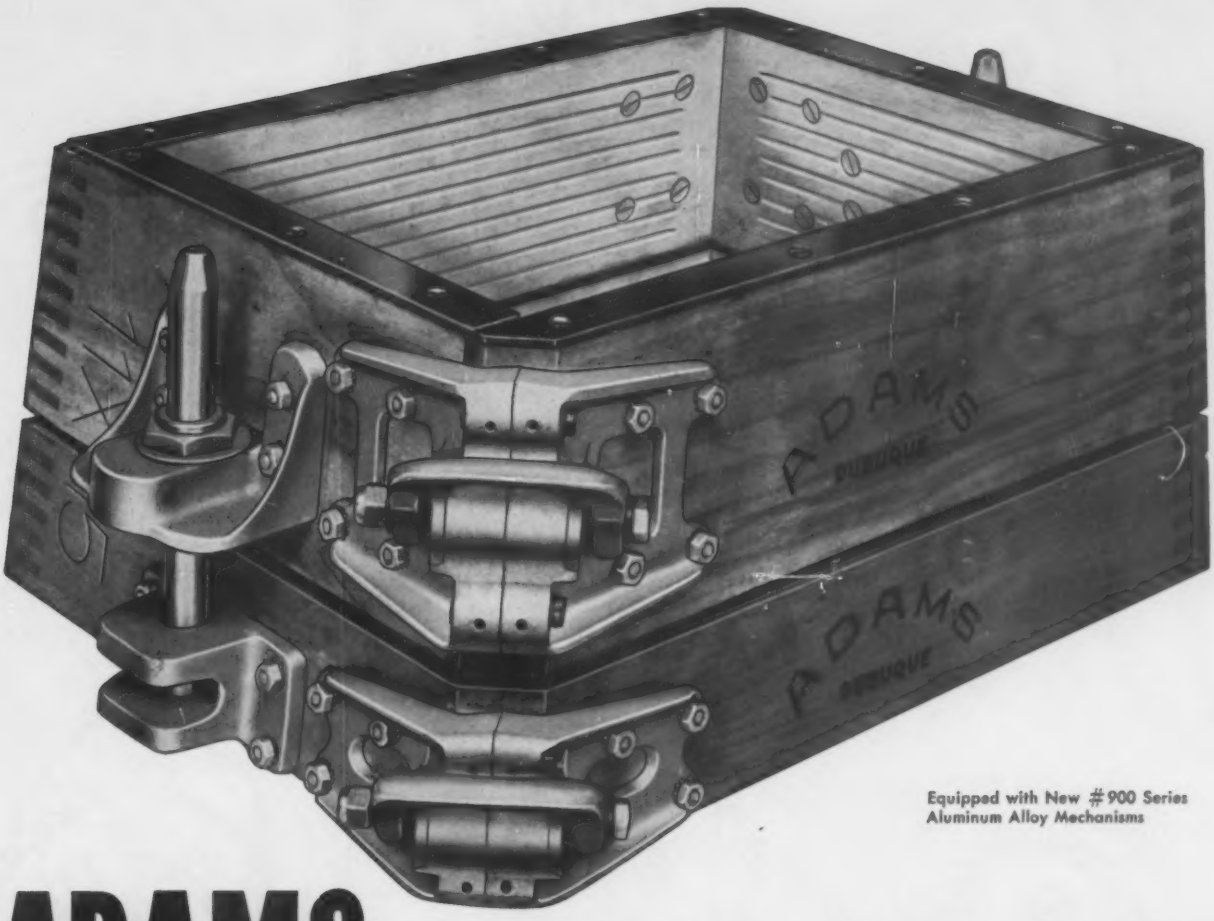

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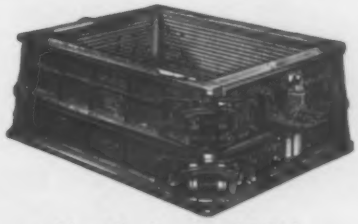

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MARKET OPPORTUNITIES

Piggy-back flat cars and other equipment improvements are helping to bring the nation's railroads out of the red. Metalcasters can share the profits if they produce higher quality castings at lower prices.

Modernization Spurs Rail Comeback

STIMULATED BY SUCCESS of the piggy-back and containerization concepts and bolstered by higher operating speeds, the railroad industry is making a comeback.

The industry is exhibiting renewed confidence in its ability to stabilize its downward trend and recapture ground lost during the last decade. This is good news for metalcasters who annually sell over $107 million in castings to railroads and suppliers and want to sell more. Many railroads have announced plans to spend sizeable sums to modernize in 1961.

. . . Atchison, Topeka & Santa Fe—$65 million including 1750 new freight cars.

. . . Burlington Lines—$13,200,000 for 1100 freight cars and $6,840,000 for 36 diesel locomotives.

. . . Chicago and Northwestern—$20,750,000 including $12 million worth of passenger cars.

. . . Great Northern—$22 million, partly for 650 freight cars and rebuilding 18 diesels.

. . . Louisville and Nashville—$45 million, with $5.6 million going toward rebuilding freight cars.

. . . Milwaukee Road—$25 million including 750 new 50-ton box cars and $7 million worth of double-deck stainless steel coaches.

. . . Pennsylvania Railroad—will build 2500 70-ton hopper cars and 1000 ore cars for $28 million.

This is only a small sample of the building plans underway this year in the nation's railroads. Castings are an integral part of this program. Alert foundrymen must put forth extra-efforts to expand their share of this market.

The future looks bright for the railroad industry and metalcasters supplying their needs. Imaginative railroad car builders are giving the industry new tools with which to compete. Take the piggy-back innovation—this truck-trailer-on-flat-car traffic accounted for 554,000 carloads in 1960. And 1961 is showing a 33 per cent increase over '60. It's predicted that piggy-back will eventually capture 60 per cent of all rail shipments. This is a market that hardly existed five years ago.

Even newer is a triple-decked flat car for hauling automobiles—fast regaining a lost hauling market. Three years ago only 10 per cent of new-car production moved by railroads. This figure will soon reach 25 per cent as a result of tri-level rack cars.

Shock-free cars encourage rail transport of fragile materials. Electronic hot box detectors guard against bearings overheating. Aluminum boxcars, hopper cars, refrigerator cars, and tank hopper cars permit 10-15 tons more payload, 20% less dead weight. Introduction of roller bearings results in savings estimated at $144 per car annually. Pneumatic unloading speeds handling of dry bulk materials. These are only a few of

the technical advances which are making it possible for railroads to meet competition.

However if metalcasters expect to hold present business, make inroads on new markets, and fend off competitive encroachments, they must be alert to customer needs. When MODERN CASTINGS asked railroads what would lead to their use of more castings the answer was unanimous—*lower price*. Castings now cost about 23-26 cents a pound while structural steel is 7 cents a pound. The differential permits a lot of welded fabrications to be priced under castings.

Technology Meets Challenge

In times of rising labor and raw material costs this challenge can only be met by more in-plant efficiency, increased productivity, better quality control, and applied technology. Comments aimed at casting improvement were many:

"Achieve closer dimensional accuracy to reduce or eliminate entirely the machining of castings.

. . . Improve metallurgical control to avoid porosity, shrinkage, cracks, metal laps, and poor surface

. . . Develop better strength-weight ratio and corrosion resistance

. . . Produce castings equal to forgings in price and strength."

J. J. Beach, purchasing agent for Central of Georgia Railway Co. states:

"We would like to have cast steel and riveted construction at the bolster center fillers and strikers, but the cost of this type construction has placed it out of reach of all but the most prosperous railroads. Similarly, there is no doubt but that a cast steel underframe will give trouble-free service in present day freight car applications for 50 to 100 years, but the initial cost renders it non-competitive, except in special circumstances."

The cost barrier is being hammered down by new technology at American Steel Foundries, Indiana Harbor Foundry. Here they have converted entirely over to shell molding with zircon sand—the first steel foundry to take such a major step.

AFS can cast steel brake beams to closer tolerances with better finish, drastically reducing expensive cleaning room and machining operations.

An industry-wide project to standardize truck side frames and bolsters is now underway in an effort to lower manufacturing costs. Railroads and foundries are plagued with the expense of providing replacements for 1,400 different designs of side frames and bolsters. This means some 1800 base patterns ranging in cost from $10,000 to $25,000. Reducing this variety to one or two basic designs would reduce manufacturing costs, inventories, lead time for making casting replacements, and time for repairs.

By engineering all the best features into several basic designs, the result will be a superior component best suited to the requirements of user and producer. The standardization has already been accomplished in the case of couplers.

What castings are needed to build railroad freight cars? Purchasing agents of leading railroad car builders and repairers reported to MODERN CASTINGS that they are currently buying the following castings:

Steel—Couplers, knuckles, side frames, bolsters, yokes, brake beams, underframes, body center plates, center filler and backstops, strikers, hopper door frames, locks, hasps, draft gear parts, draft lugs, and wheels

Malleable Iron—Centering coupler devices, hopper door hinge butts, brake heads, uncoupling rod brackets, strikers, bell cranks, front and rear draft lugs, and body center plates.

Gray Iron—Brake shoes, pipe fittings, stove parts, grates, manhole covers, and wheels.

Brass—Journal bearings.

A typical freight car uses two sets of steel couplers and knuckles, totalling 2,000 lbs and four steel side frames and bolsters weighing 2600 lbs total. Railroad car and locomotive builders annually buy more than:

186,000 tons— $21,900,000— chilled car wheels
36,000 tons— $18,000,000— gray and malleable castings
93,000 tons— $36,000,000— steel castings
130,000 tons— $29,000,000— steel wheels
600 tons— $800,000— copper base castings
680 tons— $1,370,000— aluminum base castings
446,280 tons—$107,070,000— Total Castings

To this can be added the cast manganese steel frogs, crossings, knuckle rails, and switch point tips that take the wear and tear of this rolling stock.

Railroad purchasing agents have definite opinions about the use of castings. One points to the intricate shapes that can be manufactured more economically by casting than by another fabricating means. One credited castings as more easily designed to distribute metal for localized strength in critical areas.

Castings Cost Less

Castings, they said, are stronger and can be produced at lower cost; there is an advantage to using cast steel underframes which are durable, light in weight and comparatively easy to repair; and castings by far offer the greatest measure of total economy in terms of first cost, cost of installation, and minimum maintenance with maximum service life.

The buyers also credited steel castings with lower unit stresses and a greater ability to be annealed and welded. They require no finishing and possess good impact qualities.

Many of the foundries serving the railroad industry conduct extensive product development research aimed at improving railroad operations. American Steel Foundries owns an experimental test train of three passenger and two freight cars. The rolling laboratory permits study of new designs in trucks, wheels, and brakes. The result is a smoother, faster ride for bigger loads of freight .National Malleable and Steel Castings Co. is another metalcaster which has developed a market for its couplers, trucks, and other railroad components through research and product development at its Technical Center.

The Railroad Products Division of American Brake Shoe Co. has developed a new cast cartridge journal bearing which can take the

punishing heavy loads and high speeds now par for railroad car service. This new design will put foundrymen back into the market which they have been fast losing to roller bearings because old fashioned journal boxes just couldn't give the service needed.

It is this imaginative approach to market developments that assures castings a growing position of importance in tomorrow's products. One of the most important points brought out in MODERN CASTINGS' First Invitational Metalcasting Seminar– see page 46, June issue–was the need to develop creative sales engineers with the imagination to discern new casting applications. Well engineered castings mean more profitable operations for customers and in turn more business.

Today railroads move more than 600 billion ton-miles of freight a year. They have been able to haul bigger loads at higher speeds only because cars and locomotives are built with stronger metals fabricated to meet new demands of modern design.

Practically every improvement in railroad operating capabilities is reflected in more stringent quality demands for metalcastings.

A major step forward was the cast steel wheel. Within a short span of 10 years they have virtually taken control of the market. Why? Because faster operating speeds and heavier loads require high strength wheels.

The average life of a steel wheel is 250,000 miles. This is 2½ times greater than the 100,000-mile life expectancy of a chilled iron wheel. Since the average car rolls about 17,000 miles a year, a steel wheel lasts about 15 years as compared to six for iron. The steel wheel costs $70 as compared to $43 for an iron wheel.

Steel Wheels Take Over

In 1960, chilled iron wheels produced in the U.S. for domestic use totalled 509,000, weighing 186,000 tons, and valued at $21,900,000. Cast steel wheels totaled 416,000 weighing 130,000 tons and were valued at $29 million.

Suppliers predict that steel wheels will be used on all freight cars within the very near future. With this eventual replacement market levelling off at one million wheels per year, this means a $70 million market for cast steel wheels.

One technological breakthrough –the controlled pressure pouring process (featured on the cover this month)–is a development of a foundry. The process utilizes air pressure to force molten steel from a furnace up through a ceramic tube into a semi-permanent graphite mold. The controlled rate at which steel is introduced into the mold results in a wheel cast to closer tolerances (0.020 inch) with a superior surface finish.

The modern Diesel-powered locomotives are being built at the rate of close to 1,000 a year. These use many cast parts–gray iron cylinder heads, pistons, liners; steel truck frames and underframes; and aluminum housings. Casting weights range from two ounces to two-tons for the truck frames.

There are about 1,500,000 freight cars now in service and some 29,000 passenger units. Freight car building this year has been behind 1960, but new orders are showing encouraging increase.

Repairs Play Major Role

New car building doesn't tell the whole story. Before a freight car is scrapped, it may be rebuilt several times. Worn out castings are among the parts replaced during such a major overhaul. In 1959, more than 240,000 cars underwent heavy repairs. Another 120,000 sat idle awaiting the time when they would be needed. The industry repairs more cars when business is good.

The railroads do most of the rebuilding and repair work themselves, but most of the cast parts are purchased from foundries that cater to the rugged needs of railroad service.

It is no secret that railroads have been bogged down for some time in problems of their own making as well as those created by competition and some unresolved tax problems.

Their answer has been a comeback–with the piggy-back concept loading the way. As the industry captures more business, it will begin to expand and modernize its service at a faster fate. Alert metalcasters will want a share in this market.

A Special Report

by JACK H. SCHAUM

Assisted by:

J. R. Beach
Central of Georgia Railway
Savannah, Ga.

G. E. Bennett
Chicago & Eastern Illinois RR
Chicago Heights, Ill.

R. G. Bishop
Norfolk & Western Railway
Roanoke, Virginia

W. W. Boyce
Central Railroad Co. of New Jersey
Elizabethport, N. J.

Howard Crouse
Texas and Pacific Railway
Marshall, Texas

C. T. Crumrine
Chicago and Northwestern Railway
Chicago, Ill.

Paul H. Day
Bangor & Aroostrook Railroad
Derby, Maine

H. V. Gamper
Illinois Central Railroad
Chicago, Ill.

W. A. Gibbs
Richmond, Fredricksburg & Potomac RR
Richmond, Virginia

J. T. Healy
Louisville & Nashville RR
Louisville, Ky.

E. A. Heilmann
Chicago, Rock Island & Pacific
Chicago, Ill.

G. J. Hoffman
Pennsylvania Railroad
Philadelphia, Pa.

A. S. Kasper
Western Pacific Railroad
San Francisco, Cal.

L. C. Walsh
Atlantic Coast Line Railroad
Jacksonville, Florida

G. T. Wickstrom
Union Pacific Railroad
Omaha, Nebraska

CO_2 Techniques Mean New Profits for Small Foundries

Core and mold making techniques can open the door to better and faster production for smaller non-ferrous shops. Extremely fine sand, dextrose and fly ash additives used in CO_2 process are keys to new method.

METALCASTING PROGRESS BASED ON NEW TECHNOLOGY

SEPTEMBER, 1954

MODERN CASTINGS published the first article on the use of CO_2 for hardening sand molds—by its German inventor, Dr. W. Schumacher.

JUNE, 1958

MODERN CASTINGS article announced use of molasses in CO_2 process sands to improve green compression strength.

SEPTEMBER, 1959

NEW TECHNOLOGY reveals benefits of adding sugar to CO_2 process sand to improve collapsibility.

DECEMBER, 1959

MODERN CASTINGS article describes how dextrose helps core collapsibility as much as 50 per cent in gray iron foundry using CO_2 process.

By Frank H. Donnelly
Production Mgr.
Pittsburgh Brass Mfg. Co.
and
David Longeuville
Corn Products Sales Co.

Sharp surface detail, speed and lower production cost obtained by two smaller brass foundries point up that size is no barrier to technology.

Pittsburgh Brass Mfg. Co. and Brass & Bronze Casting Co., jointly-owned foundries, have refined their sodium silicate CO_2 core and mold making process to where brass castings can be produced to tolerances as close as 0.010 in. Currently up to one-third of the cores are made without gassing while gassing time on other cores has been cut 20 per cent.

An extremely fine sand, 130-150 AFS grain fineness, and a burnout additive of pulverized dextrose with fly ash as an extender, are keys to this new method. Originally the dextrose was used as an aid to collapsibility. However, the side benefits of improved surface finish and elimination or reduction of gassing times have contributed to the success of the process.

Output of the foundries is about evenly divided between captive and jobbing work. Castings are made for blast furnace fittings, tuyere cocks, unions, transformer and other electrical fittings, valves, mill bearings, and bushings. Solid bushings are the heaviest castings produced, running 300 to 500 lb. Most work, however, ranges from 1/2 to 5 lb, in quantities from one casting to 20,000. Many smaller castings require extremely sharp surface detail.

Castings are made in manganese bronze and aluminum bronze, but bulk is in various brasses.

Both bench coremaking and core blowing are used. The method selected depends on the geometry of the core.

The foundries have used the sodium silicate CO_2 process for approximately four years. Two years ago the process was evaluated and continued because of:

1. Maximum flexibility.
2. Ease of setup.
3. Fast production.

Today the process is used for practically all cores and mold facings. Rush jobs can be put into work in half an hour.

Sugar was first used as a shakeout additive, initially in the form of syrups. Granulated corn sugar (dextrose) offered further improvements. Currently, due in large part to the sand fineness, the foundries are using a pulverized dextrose of small particle size in combination with fly ash. The sugar accelerates the curing while the fly ash provides economy and improved release.

This mixture provides excellent collapsibility, better peel of sand from metal, easier shakeout and core knockout, and improved surface finish. Other benefits include increased green strength and less need for cleaning up of finished castings due to the good peel and shakeout.

Gassing of cores is done at 20 psi, mostly by means of gassing cups, but occasionally with a lance probe. Cores needed fast for rush jobs may be overgassed a few seconds. If cores can be stored, they are under-

Placing a CO_2-hardened core in a large-bench green sand mold. Foundries have found the process offers maximum flexibility, ease of setup and fast production.

Both bench coremaking and core blowing are used, depending upon core geometry. These blown cores are among those made without gassing, the dextrose promoting air setting of the sodium silicate.

This unique setup of a semi-automatic core and mold blower and two semi-automatic gassing stations has a production capacity of 400 molds in average size bench flasks per day. Hardened mold is ejected from one original flask after gas-hardening, eliminating need for extra flasks.

This group of more difficult cores have some extreme overhang. These are hand-rammed in aluminum core boxes. The dextrose contributes green strength and better collapsibility as well as improved surface finish of castings.

Smaller cores, usually without overhang, are made without gassing. This has not caused any quality control problems, and still the cores are readily handled and worked, and core breakage is nil.

gassed or cured without gassing, depending on the requirements of individual cores.

The dextrose has enabled the foundries to make from 1/4 to 1/3 of core production without gassing, and to reduce gassing time on the balance. It has been the experience of these foundries that dextrose shortens necessary gassing time by about 20%, when mixed in proper proportions. Air setting has not been fully evaluated, but some setting up, or skin hardness, becomes apparent after about five hours.

In general it is the smaller cores without overhang that are made without gassing. On these, there is no quality control problem due to elimination of gassing. Ungassed cores are normally used in 18 to 24 hours. This time can be decreased, if desired, by slight baking. The practice followed is dictated by the foundry schedule. Storage space is limited and the core room is usually operated on a one or two day lead.

Size or geometry of the cores has some effect on the time interval before ungassed cores are ready for use. As the size increases, however, if the increase in the exposed or surface area is proportional to increases in girth or section, the curing time will remain fairly constant.

Ungassed cores are readily handled and worked, and core breakage is nil. There is little moisture pick-up in stored cores; the increase in moisture content does not amount to more than 0.2%, even in humid weather.

Sand mixes are made in 300 lb batches. The percentages of binder and additive used are increased slightly for mixes intended for cores with overhangs, as shown by these formulations:

Sand Ingredient	Standard Mix	Overhang Mix
Sand, 130-150 AFS grain fineness	300 lbs	300 lbs
Sodium silicate, 50.5 baume	3%	4%
Cerelose pulverized dextrose #2063	1½%	2%
Fly ash	1½%	2%

In both mixes the combined dextrose and fly ash added exactly equals the percentage of sodium silicate. Sand is stored indoors so it will have uniform low moisture content.

The additives disperse readily and evenly in three to four minutes mulling time. The cycle is as follows:

Sand and dextrose, dry	1 min
Add fly ash, dry	1 min
Add sodium silicate	1 min
Kerosene release	½ min

A heavy wheel muller of the closed type is used. After mulling, core sand is stored in 150 lb containers and kept covered until it is needed.

To eliminate sticking, lacquer is used to coat aluminum core boxes, and a dry parting powder is dusted onto wooden boxes, especially those involving deep draws.

Use Two Gassing Stations

An interesting feature at Brass & Bronze Casting Co. is a semi-automatic core and mold blower and two semi-automatic gassing stations.

A standard type of coreblower has been rebuilt for blowing and squeezing molds as well as blowing cores. It has a capacity of 20 lbs. and operates on a constant time cycle. Production capacity is 400 molds in average size bench flasks per day. The sequence of operations for mold blowing is as follows:

1. Place flask and pattern under blowing head
2. Elevate table and blow
3. Lower table and advance squeeze head
4. Raise table and squeeze
5. Transfer flask to one of two gassing stations.
6. Gas, for preset time period
7. Strip hardened sand from pattern frame.

The hardened mold is automatically ejected from its flask by stripper pins. The flask and pattern then go back to the blower.

Since hardening with the CO_2 only requires a few seconds, the speed of the process can be appreciated by the fact that two gassing stations are needed.

These core and mold making techniques may open the doors to better and faster production for other small non-ferrous shops.

Portable Hoppers Slash Core Room Costs 15%

Fork lift trucks deliver 2000-lb loads of mixed core sand directly from storage racks to the coremaking station. Specially built steel hoppers are the key.

By William D. Dunn
Oberdorfer Foundries, Inc.

Core production costs have been cut 15 per cent at Oberdorfer Foundries through faster mixed core sand deliveries. The key to the money-saving system are one-ton portable steel hoppers moved by fork lift trucks.

Formerly two men with wheelbarrows delivered the sand to the coreroom. Now a fork lift truck operator devotes only a portion of his time to this function.

The 2000-lb capacity steel hoppers, designed by Oberdorfer engineers, are easily moved from the storage area to the sand mixer, stored, or placed above the coremaking stations on the production lines. The two-tiered storage racks, also designed and built by company personnel, hold either loaded or empty hoppers and are located near the sand mixing unit. The lower hoppers are located high enough off the floor to allow use of a wheelbarrow for transporting small batches of sand to the short order core benches.

Hoppers are suspended from the top flanges which are introduced into angle supports over the coremaking station. Stops are placed at the rear of the angles for locating purposes. Safety guides are welded to the under side.

A unique advantage of the system is that it allows the mixing unit to be used to capacity. Sand that is not used immediately can be stored. A plywood cover reduces the moisture loss and provides better control of sand mixes.

Another advantage is the improved housekeeping and reduced safety hazards. The system eliminates storing various batches of sand on the floor or in bins and also saves the operation of shoveling sand from the floor or bins back into a wheelbarrow to deliver it to the coremakers benches.

Handling of both small and large batches has been speeded considerably. The fork lift truck swiftly moves the bins from the sand mixer to the storage racks or to the coremaking stations. Hand operations also have been made faster and more convenient.

The system provides a type of overhead sand handling combined with the flexibility of the fork lift truck. It requires less floor space than the former method while at the same time providing cleaner working conditions and improved plant safety.

One-ton loads of sand from the mixer are stored in these two-tiered racks until needed. The fork lift operator can carry a fully loaded hopper, or small loads can be drawn out and carried by wheelbarrow.

Full loads are taken directly to the production line and suspended above the coremaking station. This is only a part-time job for the fork-lift operator.

Sales Engineering—Success Story at Superior Steel

By JOHN W. LANE

American technology is proceeding at a rapid, sometimes break-neck, speed. Constantly nudged by an impatient economy that develops greater and more taxing demands on it almost daily, industry is sometimes hard put to determine direction, spot trends and try to jockey into a position one jump ahead of demand.

In the metalcasting industry creative selling and development of new marketing techniques frequently have been slow in coming. Traditional concepts often have shouldered out ideas aborning before the doctor had a chance to spank the baby's bottom to see if he could yell.

Designers and engineers have been raked over the coals by such authorities as Jack Caine who accused them of "timidity" at the 65th Castings Congress in San Francisco last May.

Maybe so, but many metalcasters are learning how to compete more effectively today by taking and maintaining initiative. As MODERN CASTINGS *reported in its May, 1961, issue, a nationwide survey revealed that five principles must be applied if new market opportunities are to be grasped. One of these five is creative sales engineering, an art that has reached sophistication in relatively few metalcasting firms.*

Sales engineering is truly a marketing concept, not simply a means of snatching an order away from another foundry. By supplying the customer with creative support at the design level, sales engineering builds the total market by taking business away from competing industries.

WHAT HAPPENS when management takes a good, hard look at foundry sales? Is the picture pleasing? Do sales reflect constant progress? Or is there something vital missing?

In Benton Harbor, Michigan, Superior Steel and Malleable Castings Co. has been in the metalcasting business since 1916. Its sales techniques followed the same pattern as most foundries until about 10 years ago. Then, Ross L. Gilmore, president since the death of his founder father, was brought up short.

Although himself an engineer, Gilmore, as chief executive officer of the company, had delved deeply into all phases of the metalcasting business. He was on hand to watch the first pouring at Superior in 1916, and his early wonderment turned to professional acumen over the years. Marketing, and particularly sales, attracted a good deal of his attention in recent years.

Analyzing his own business and that of the metalcasting industry generally, Gilmore was struck by three thoughts:

1. Most foundry problems resulted from poor original foundry design.
2. His major competition came from other industries, not from other foundries.
3. The reason that the metalcasting business didn't get a good deal of work being handled by other processes was that too many metalcasting salesmen were order takers, not creative salesmen.

The key to industry expansion—and that of Superior—obviously was to find a way of presenting a creative marketing service rather than just the facilities of a first class foundry. Sales engineering, Gilmore decided, was the answer.

To develop an effective sales engineering program, he took several important and radical steps. First he established an up-to-date laboratory and staffed it with the most competent engineers he could find. Then he began to put together a sales training program that would eventually snugly fit into the experimental engineering function.

Finally, he faced the problem of presenting this radical new concept to potential customers. Although

sales engineering in itself is not new, it was spanking new to the metalcasting business in 1951. Persuading customers to accept this new approach is still one of the troublesome aspects of the entire program. Too many customers thought of castings as second grade parts. They were afraid to try.

In developing engineering facilities Gilmore looked long and hard for a man who combined the practical knowledge of the foundry floor and pattern shop with that of an academic background. Robert J. Franck, now chief engineer, filled the bill.

Franck became a pattern maker before World War II. Following his release from the Armed Services he obtained his engineering degree so that, as he puts it, "I learned the vocabulary to go along with what I knew."

When Superior's laboratory was first established, most of its work was confined to a study of problem castings. In such cases, Franck and his staff would study the casting from its concept to determine why it presented difficulties. Sometimes they would go so far as to design a modification of a casting, make a pattern for it and then go back to the customer with their recommendations.

"Particularly in the first few years," admitted Franck, "we ran into touchy situations. Nobody likes to be told he is wrong, least of all a customer. But we learned to present our recommendations in such a way that we avoided offending all but the most thin-skinned."

Stress Analysis Lab for Customers

At about this time, Gilmore became convinced that he had found the proper formula for market development and decided to go one step further. He had Franck begin to design and assemble a stress analysis laboratory that would be able to cope with customers' problems from the inception of an idea.

Superior's program of sales engineering was considered by many to be radical and unworkable—that it overstepped a metalcaster's functions by usurping some of the engineering functions always thought of as in the customer's domain. The program is still radical but the fact that it works, and with some of the biggest users of castings in the country, is proof enough of its value.

Modest Ross Gilmore says he "sometimes wonders how they managed to do it." But a study of the Superior operation shows clearly that success is punctuated by having fixed a goal and then doggedly driving towards it despite criticism and setbacks.

Early in the establishment of Superior's program, Franck detailed a 10-point outline of product development. Now, 10 years later, the outline is still followed by engineering and sales personnel without a change having been made. The outline is simple to understand and its logic makes it hard to argue against. In fact, metalcasting engineers might be inclined to shrug it off with a "doesn't everybody," comment. But do they?

The outline is followed by salesmen when discussing problems with customers and it is so designed that all 10 points need not be developed. In some instances the first three or even the first five points may be dropped. Ideally, that is when Superior can get in at the idea stage, all 10 points are followed closely.

At the first customer contact, the Superior salesman asks the critical question: "Why cast it." If he and the customer agree that the part lends itself better to casting than to a weldment, for example, a study of the problem is made. Otherwise the salesman steps out of the picture with the recommendation that another process be used.

"We don't believe in taking work that rightfully should not be cast," Gilmore explained. "This would eventually blacken our name and would do the industry a disservice."

Give Up One Order for Six

Of course there are exceptions. Franck recalls that Superior cast many thousands of a small part during the Korean War that really should have been stamped. When the emergency was over and stamping facilities once again were available, Superior suggested to the customer that he return to stamping the part. "We lost the business, of course," Franck admitted, "but we held onto a customer, and the relatively small order was replaced by six orders for parts that were better cast than formed otherwise."

If the decision is made to cast, Superior's engineering-oriented salesman follows up by establishing how much time is available for product development work, if the present design is functionally satisfactory, and if it is acceptable structurally and foundry-wise. He gets the service experience when possible, inquires about weight-saving possibilities, and determines the cost factor.

Next a proposal is made to the customer for product development. In the proposal, both development and production are detailed as specifically as possible.

The third step is often a crucial one. Superior laboratories evaluate present design by experimental stress analysis. Both static and dynamic testing is done. The company has modern equipment that it takes into the field where the part being studied is analyzed by means of stress gauges.

These three steps amount to phase one of the over-all plan. Back in the laboratory, Franck's staff begins the painstaking job of analyzing product design. Step four consists of an evaluation of function (will it do the job), structure (how long will it last), a study of proportions and change in shape, weight and the castability of the part.

Following this analysis, free hand sketches begin the fifth step that consists of method of product design. Mock-ups are made, and the pattern shop and foundry are consulted. Then engineering drawings of the new or modified design are prepared and, finally, pattern layout and construction are determined.

This marks completion of the second phase and Superior is now ready for production of sample castings. As step six, casting the first samples involves

Can Small Metalcasters Offer Sales Engineering?

To be any good at all, a sales engineering approach must, of course, be backed up by a substantial outlay in laboratory equipment and high priced talent. Does this mean that a plan cannot be devised for the smaller foundries?

It seems likely from a study of Superior's operation and its success that a consulting service for smaller firms would be a practical and feasible means of providing adequate engineering facilities to smaller metalcasters. However, such a service could not operate profitably unless and until a sufficient number of metalcasters adopt the philosophy of sales engineering.

A consulting service, operating on a fee basis, might well be the answer to broadening the application of sales engineering. Smaller metalcasters could train their salesmen to sell in a manner similar to Superior's and then the actual engineering including stress analysis would be handled by the consulting firm.

This is an idea that merits serious thought by the metalcasting industry and one that will probably be carefully examined in coming months and years as the values of sales engineering become more evident to the industry.

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close engineering follow-up with the molder, engineering inspection using X-ray and determining dimension weight and finally machining the finished part.

The next step is referred to by Franck as "grading your paper," but it's no joke. Once again experimental stress analysis is brought into play and the newly designed and cast part is carefully evaluated.

Step eight involves modification of the new design when stress distribution can be improved by adding or removing metal adjacent to highly stressed areas.

Nearing the end of the product development, the new design is re-evaluated before the final step, customer approval for production release.

Not a Simple Job

Developing a sales force to complement Superior's unique engineering facilities was no mean task. Most of the burden fell on Lloyd Young, sales manager, who was one of three salesmen in 1951. Today, Young directs the activities of 14 men in the field.

Gilmore's original concept called for all salesmen to be engineers. But he quickly modified this view and now is satisfied to have sales handled by college trained men who show an aptitude and liking for the metalcasting business.

As the sales staff grew, two methods of adding men were tried. Some experienced men were hired and trained in the Superior concept of sales engineering. But some young men fresh from college were also taken on. Obviously the experienced men could go into the field a great deal sooner than the greenhorns. Men new to the industry are apprentice trained in Benton Harbor for at least two years, sometimes longer.

Both methods work, and Young is not committed to either one. "If I had to hire two or three men tomorrow," he says, "I really wouldn't know which type to look for. A lot depends on the man."

Obviously, the Superior sales engineering plan made some false starts in the beginning. But over the years sales, engineering and top executive talent have blended into a single smooth-working team.

Young points out that salesmen run into some difficulty when they try to get in at the idea stage of product development. This obstacle has been partially, at least, overcome by preparation of a four-color, sound movie, "The Big Difference", made in Superior's plant and in the field during actual dynamic testing of parts in use.

Film Travels Everywhere

Made about five years ago, many prints of the film are in constant use by salesmen calling on customers and on loan for showings to engineering meetings or groups of engineering students. Superior salesmen have portable projectors that can be placed on a customer's desk for showing to two or three persons and they also carry standard projection equipment for showing to larger groups.

If any single factor can be said to have contributed to the sales engineering program's success, says Lloyd Young, it is probably the film.

"With the film," he emphasized, "a salesman can show exactly what we do and how we do it. I guess the film has opened the doors to more customer engineering departments than anything we do. We are sold on its value."

In addition, Superior salesmen are taught to be alert and recognize possibilities for metalcasting business when they are in customers' plants. Whenever possible, they look over assembled equipment and parts as they walk through plants with an eye to possible metalcasting jobs. It is this ability to recognize a potential job, says Young, that characterizes a good salesman.

If a salesman can talk to a customer's sales manager rather than someone in the purchasing or procurement division, he can usually get further. But this can be tough to do. Sometimes Lloyd Young goes into a territory with salesmen and works with them for from two to three weeks. The combination frequently breaks down the stubborn resistance that has held the salesman back.

Superior holds two or more sales meetings each year. All salesmen are brought to Benton Harbor where they spend a week or more of intensive sessions with management and engineering. Problems are aired and discussed and new approaches are worked out.

The sales engineering technique has helped Superior grow over the years from about $2,500,000 sales in 1951 to more than $6,500,000 in 1960. From a sluggish start, 1961 has picked up considerably in

the first half and Gilmore looks forward to substantial improvement before the year is out.

Presently, about 30 per cent of Superior's production is in engineered products. They hope to increase this to 50 per cent or more by 1965. "We don't believe our goal is unrealistic," Gilmore explained. "It's a question of educating the customers and educating our own industry. We make no effort to conceal our methods from other foundries for we sincerely believe that if more metalcasters would use the sales engineering approach, there would be more, much more business for us all."

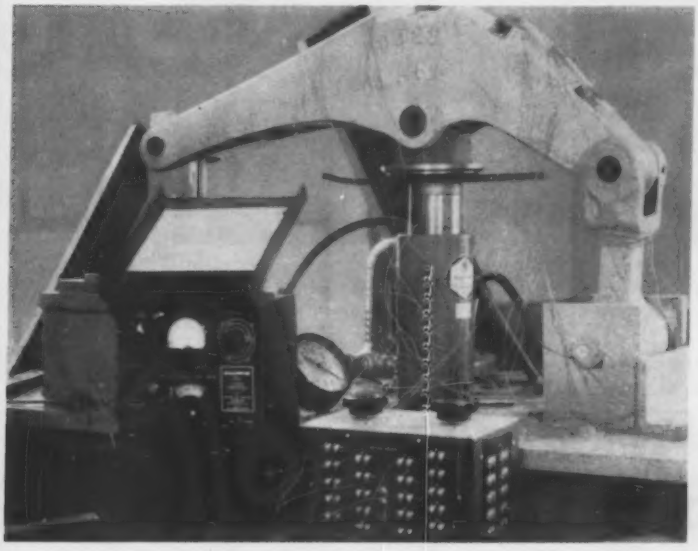
A significant development, says Gilmore, is the rising importance of appearance in merchandising industrial and other metal parts and products. "This is where we have missed the boat as an industry," he declared. "Merchandising is a word that belongs in our vocabulary just as well as it belongs to those who produce packaged goods.

"Pleasing appearance that is aesthetically tempting is a big selling point in the metalcasting industry. Many times a part can be cast that will be far more appealing to the eye than one fabricated by other means."

Gilmore believes that salesmen should always list the advantages of engineering a casting for a prospective customer so that an accurate comparison with other methods can be made. Advantages usually are:

1. Reduction in weight.
2. Redesign to overcome such problems as shrinkage, excessive rejects, gating and risering, cracking, excessive machining and others.
3. High costs.
4. More pleasing appearance.

If the metalcasting industry concentrates on creative selling, borrows ideas and techniques from other industries, follows trends and user demands, Mr. Gilmore concludes, there is no doubt that in coming years, the industry will grow in breadth as well as in depth.



Complete stress analysis service, both in the Superior laboratory and in the field, is one way that the company helps the customer in product development. The sales engineers carry each project from beginning to final approval for production release.

This completely unitized pig babbit load of 4000 lbs is held together by two steel straps. It sits on pigs cast with legs, thus eliminating the need for any pallets. This ultimate in unitization resulted in an annual saving of $35,000 for Allis Chalmers.

Unitize and Palletize to Cut Materials Handling Costs

By John H. Bates
Allis Chalmers Mfg. Co.

Every time one man moves two items instead of one, he cuts the labor cost by 50 per cent. When he moves five items at one time, labor costs drop 80 per cent.

Raw materials can move into a foundry as a unit and castings can move out to a customer as a unit—saving hundreds of dollars in handling, space and freight charges.

It's a simple economy to install in any plant, but it takes time and a coordinated effort to make it a paying proposition for everyone concerned.

INDIRECT LABOR COST savings of 80 to 95 per cent in the handling of incoming shipments of raw materials, in-process materials and finished materials have been effected at the Allis Chalmers Manufacturing Co. in Milwaukee.

Two modern, efficient materials handling methods—unitization and palletization—are responsible for bringing a greater manufacturing cost reduction than possible in any other department for each dollar of investment.

Material handling expense varies from 20 to 45 per cent of the total manufacturing labor cost in most industrial plants today. Every time one man moves two items instead of one, he cuts labor costs by 50 per cent. When five items are moved instead of one, labor costs drop 80 per cent. If 20 items are moved at one time, the savings go up to 95 per cent, and so on up to any physical quantity. In the face of constantly rising labor costs, any savings effected by cutting this expense go directly into net profit.

The best material handling is no material handling at all. The next best method is movement of all materials in unitized or palletized loads by mechanized equipment from the time it is received, into storage, and into the first foundry operation, without breaking the unitized load.

This has been achieved in many areas at Allis Chalmers with great success. Suppliers have been convinced that shipping unitized loads offers bi-lateral savings. At the same time unitization offered immediate relief to already-crowded receiving areas, and in-plant movement efficiencies afforded even further gains.

By formulating a comprehensive program of unitization, a foundry can eliminate all handling of individual items from the time they leave the supplier until the material is ready for use. The program reduces "in plant" transportation expense because bigger and heavier loads can be moved with fork lift trucks and other equipment designed for this job. It cuts the cost of handling "in-process" materials between casting, shakeout, machining or assembly operations. It offers a final advantage as well —shipment of unitized castings to customers who in turn share material handling cost reductions.

While the major benefits accrue from savings in receiving and shipping of raw materials and castings, the other areas of in-plant and in-process handling can be very important.

By unitizing heat treating furnaces with specially designed racks which permit loading and unloading at high temperatures, Allis Chalmers was able to increase furnace capacities up to 400 per cent. More even heating of castings and more uniform heat treating was achieved. There was a reduction in fuel cost up to 60 per cent, and the system eliminated the need to cool down furnaces so the hitcher can get inside to remove castings.

There are nine basic materials handling principles to consider in setting up a program:

1. Handling and transportation of materials adds nothing to their value and always increases their cost.
2. Use of mechanized equipment generally increases efficiency and economy of handling.
3. Rehandling of materials is to be eliminated wherever possible.
4. Handle as many pieces in one unit as possible.
5. Standardize types of equipment, containers and methods as much as possible.
6. The value of material handling equipment is directly proportional to its flexibility.
7. Storage space is best measured in terms of cubic content used, and all air rights should be utilized.
8. Conserve productive floor space by preventing it from becoming a storage area.
9. Use existing equipment if possible, but do not in any way "hamstring" the program to use old equipment.

A major effort of coordination between the materials handling department, sources of supply, customers, and other departments in the plant is necessary to achieve unitized material handling.

The product engineering department or customer will supply information on the physical characteristics of the product and quantities required for each operation. The purchasing department can contact sources to get them to unitize their shipments according to specifications. And this department can order in quantities which will permit maximum utilization of unitized material. This may result in ordering odd quantities to prevent breaking of unitized loads before they are ready for an operation, but this is necessary for the success of the program.

The receiving department must have adequate equipment to move the unitized loads from the common carrier and to store them on pallet racks or move them immediately to the storage area by lift truck or on trailer trains.

The material stores or warehousing department should be equipped with adequate pallet racks to hold the incoming material and to use "air rights" to the maximum possible extent for storage. Storekeepers will have to be trained to leave multiple unit packages intact rather than to put the individual items in bins or shelves.

Unitize All Shipments

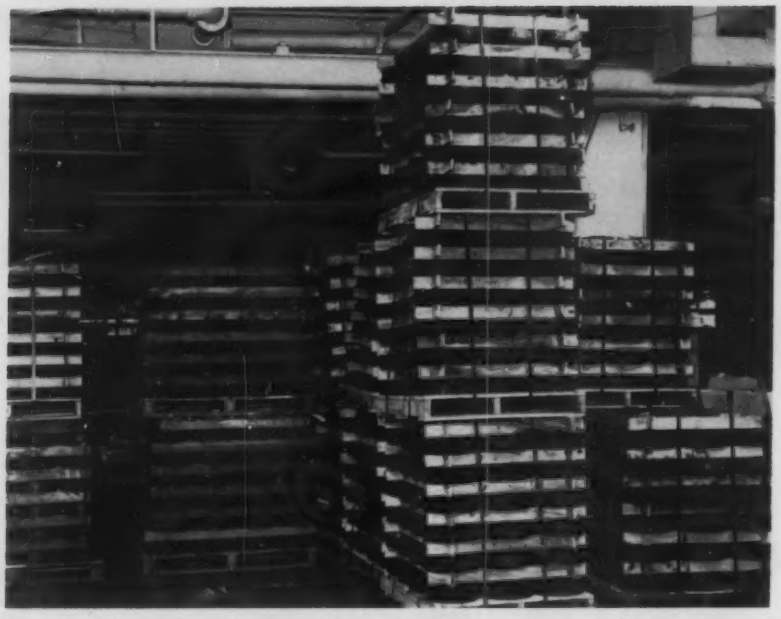
The shipping department must be equipped with all the equipment necessary to wrap or package the unitized loads going to customers. All possible shipments should be unitized, whether it means taping together two small corrugated boxes that are part of one order or making up completely unitized pallet loads of a large order.

The customer's receiving department must have adequate equipment to handle the unitized loads that will be received. A 4000-lb package creates nothing but havoc when a customer has only a 2000-lb fork lift truck to move it off the common carrier.

Finally, liaison must be close between the foundry and the railroads or truckers to take advantage of reduced shipping rates because of unitized loads—at the same time keeping the loads within the carrier's ability.

Within the plant, the first step is to list all pallets, pallet boxes, skids and shipping containers now in use. Many will be of some special size and designed for only one use or for one department. It is

It formerly took a large automobile manufacturer 56 man-hours to unload 76,000 lbs of cast-iron auto wheel drums, move them to storage and put them into storage by individual handling.



With unitized material handling, the cast-iron wheel drums are shipped on pallets. It requires 2 man-hours to unload and move them into storage, a saving of 97 per cent in one area alone.

It is a simple matter for a fork lift truck to load or unload large groupings of castings, eliminating need for stacking inside the carrier.

necessary then to decide on a group of standard sized pallets, pallet boxes, skids, skid boxes, four wheeled carts, containers or stack-bins which should be in use throughout the foundry. If more than one plant is involved, there should be standard containers for inter-plant shipments as well. This keeps the loads intact, assures adequate storage facilities and may bring additional savings by eliminating freight charges for moving empty equipment back to the original source.

There are no standard pallet or boxes used throughout industry yet, so the decision on size is up to the foundry. One important move is to stop the purchasing department from getting any additional "odd ball" sizes without approval. Once the pallets and boxes are standardized, it is easy to standardize the racks in all the areas concerned.

It will be an expensive and time consuming job to eliminate special sizes of skids and pallets, but it isn't impossible. Standardization of containers reduces the required quantity of containers in use, which in turn reduces storage space required.

It Will Be Expensive

Once the pallets and boxes are standardized, it is necessary to survey storage facilities in the receiving department, inspection department, stores areas, manufacturing department delivery area and warehouse areas. Aisle widths in these areas and throughout the foundry are important considerations for the use of mechanized materials handling equipment. Shelves and racks must be of sufficient size to hold the loads.

All fork lift trucks, platform trucks, walkalongs, cranes, and four-wheeled trucks should be checked for capacities. These will be used to unload trucks in the receiving area, move loads through the foundry, move loads in the storage area, and load outgoing castings.

It will be necessary to check the railroad, common carrier and consolidating dock facilities for their ability to handle the proposed unitized loads. Usually 4,000 lbs can be handled, but it is necessary to

determine the types and capacities of material handling facilities here as well as at the plants which supply materials in quantity sufficient to justify unitization of incoming shipments.

All of this data will determine the maximum weights and sizes of unitized loads for each source which can also be handled by the foundry equipment. Each load should be compatible with all equipment and storage facilities that will be used from the time it leaves the source until it is finally broken down into individual units.

It will be necessary to survey all incoming material at the receiving dock. A photograph of loose material that appears to need unitization while it is still in the common carrier is a good start. Case history data sheets made up for each batch of material should include the purchase order number and date, the source name and address, the date shipment received, name of the common carrier and waybill or B/L number, routing information, type of material, size and weight of each unit, type of packaging, length of time carrier waited to unload, and unloading time for each shipment (noting man hours, payroll per hour, total materials handling cost and type of equipment required).

The material should be unitized the first time right at the receiving dock, in accordance with the maximum loading weights and the standard pallets designated. It is important to carefully record the time required to unload the material at the dock since this time was probably required to load up at the source.

Photograph Is Valuable

A photograph which shows two sides and the top of the unitized load will be valuable at this point. These pictures, attached to a letter describing the unitization procedure, can be sent to the suppliers. This will eliminate many questions regarding the problem and method of unitizing the load.

The difference between cost of unloading loose material and handling cost for unitized material—plus the cost of unitization such as steel or paper strapping—gives the net material handling savings which can be expected from each source for each shipment. In addition, there will be a saving from the movement of the unitized load into the storage area.

This information will be useful both to management of the foundry and to the supplier. Armed with the facts and figures, the foundryman can visit the supplier and present his case for unitization of shipments. The supplier may agree to unitize—at an additional cost—but this is where the information can play an important role. He can be shown that he will save money by handling unitized material.

If the supplier will unitize one load on one standard pallet or an expendable pallet he can buy locally, it should be proven that the unitization savings are more than the cost. If this doesn't mean a decrease in the item cost per shipment, at least the supplier should agree to unitize at no additional cost. This is still going to save materials handling costs for the foundry.

Buy Pallets Locally

There may be cases where the supplier may be shipping materials dumped directly into the common carrier, so you are restricted to eliminating only one handling of individual items. In this case, if the foundry buys the standard pallet in the supplier's locale and furnishes them at no cost, the supplier may unitize without charge. The pallets or containers can be "replacements" for worn out units at the foundry, and there will be no extra freight cost for shipping empties.

Every material handling expense of the supplier is now included in the invoice cost. So in reality the foundry will subsidize the supplier if he continues to handle loose material. This actual figure can be determined by the cost differential between handling unitized material and loose items on the receiving dock and through the foundry.

The cost of unitizing at the supplier's end will probably be absorbed by his materials handling cost reduction, and in the long run, the foundry will achieve more production and storage space by utilizing "air rights" for storage.

Studies at the Allis Chalmers plant have revealed that one and one half man hours on a fork lift truck will unload and place in storage approximately 80,000 lbs of unitized material from a freight car or truck, provided the storage area is within 250 feet of the receiving dock. Thirty to forty-five man-minutes usually unload and place in storage approximately 35,000 lbs of unitized material under the same conditions.

Summarizing the benefits of a unitization plan, a foundry can achieve:

1. Greatly reduced materials handling costs with as high as 90 per cent cost savings and very little capital outlay.
2. Reduced "in plant" transportation expense because bigger and heavier loads can be moved with better equipment.
3. Increased customer acceptance and good will because of reduced materials handling expense in handling foundry shipments—a selling point over competition.
4. Increased receiving and shipping dock capacities—up to 400 per cent by being able to unload freight cars or trucks that much faster.
5. Elimination of the man-hours formerly required to unitize or palletize loose material in incoming shipments before it can be moved to storage or first foundry operation.
6. Considerable reduction in storeroom material handling costs by handling the right-sized loads.
7. Reduction in size of storage areas by better utilization of "air rights."
8. Reduction in freight rates because of high density loading in freight cars.
9. Lower switching rates as a result of better freight loads.
10. Improved good will of sources who now have a lower handling cost as well.
11. Possible lower cost of raw materials because of savings by the supplier.

A program of unitization and palletization can be instituted in any foundry that considers time and space as valuable assets.

It is possible to reduce sulphur levels below 0.005 per cent without substantial increase in cost over the standard two-slag process. This is what foundrymen from all over the world learned at the 28th International Foundry Congress in Vienna, Austria, in June. Here is an exclusive summary of this official AFS Exchange Paper.

Desulphurizing Carbon Steel to Extra-Low Limits

By A. J. Kiesler
General Electric Co.

Increased applications for steel castings in tomorrow's aerospace market have been opened through a new sulphur control technique. It is now possible to reduce sulphur levels below 0.005 per cent without substantial, or any increase, in cost over the standard two-slag practice. This success stems from removal of sulphur before the oxidation period.

Low sulphur cuts production costs through a reduction in hot tearing while giving improved tensile, ductility, impact strength, and impact transition temperature.

This technique takes advantage of the increase in desulphurizing ability accompanying a high lime slag contacting a metal bath high in carbon and low in iron oxide. The escaping tendency of sulphur dissolved in liquid steel is increased in activity by both silicon and carbon. The sulphur dissolved in liquid iron has over five times the escaping tendency of sulphur dissolved in low carbon steel.

Sulphur reduction has traditionally required a basic-lined furnace to maintain a slag of sufficient basicity to absorb sulphur from the metal and retain it. The optimum ratio of sulphur in the slag to sulphur in the metal requires a highly basic slag very low in iron oxide. Such conditions can be accomplished best in a basic electric furnace after a prolonged reducing treatment. The longer heat time made necessary by the slag conditioning makes the removal of sulphur an added expense.

In this investigation melting was done in a 2000-lb capacity, 625 KVA, three-phase electric arc furnace. Castings poured were standard twin keel blocks in air-fired silica sand molds.

An essential to this process is the refractory used in the furnace hearth. A magnesite hearth must be used. A dolomite hearth or dolomite patched banks will act as a desulphurizer during the reducing period and will give up its sulphur to the melt during the oxidation period. With dolomite hearths, reversions of 0.012 per cent and higher are not uncommon.

In the new process the metal to be purified is melted with conventional slagging components for phosphorus removal. Since this removal occurs best at lower temperatures, it is best to place the burned lime or limestone well down in the charge. A lime-silica ratio of 2:1 to 3:1 is usually enough to remove phosphorus from a medium carbon steel. When the phosphorus is at the predetermined level this oxidizing slag is removed.

At this point an addition of 0.10 to 0.15 per cent aluminum pig is added to aid in the desulphurizing. The activity of the sulphur is enhanced by aluminum and is further aided by the high "melt in" carbon of about 0.60 per cent. Silicon could be added.

A second slag is premixed, using two parts of lime, one part graphite, and one-half part of finely divided ferrosilicon. The carbide slag is worked into the heat when the slag and metal reach equilibrium.

This can be done by rabbling, use of inert gas, or in larger furnaces, by induction stirring.

At General Electric, carbide slag, while on the melt, is rabbled four or five times with a rake or straight bar using an up and down motion.

It is important to avoid splashing slag in the furnace side walls during mixing. When the desired sulphur level is reached, the slag is completely removed. Any slag remaining on metal or sidewalls will revert its sulphur during subsequent processing. Reversions of 0.002 per cent have been recorded.

The next step is to oxygen blow the melt to oxidize carbon, manganese, silicon, and aluminum. During this operation the metal is protected from sulphur-bearing materials and the sulphur content is maintained at the minimum established in the desulphurizing operation.

At General Electric, heats are oxygen blown after the removal of the carbide slag without the addition of a new slag. The products of oxidation are sufficient to protect the bath. No significant difference has been found in the life of the refractories when blowing a bare bath. Other investigators using this process have added a second basic slag before the oxygen blow to further the removal of phosphorus.

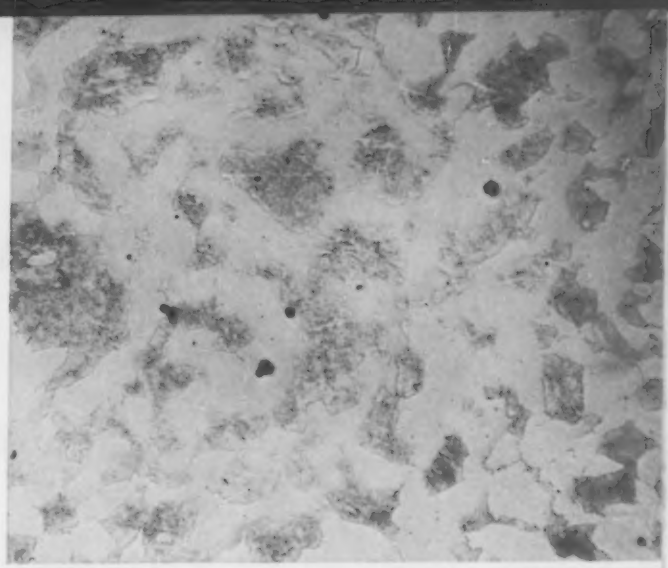
The final step following oxidation is to treat the metal with silicon and manganese additions, tap and cast in accordance with conventional practices.

The hydrogen and nitrogen content of the steel made by this process should be very low due to the short time interval between the oxygen blow and the tapping. Many investigators have shown that these gases are at the lowest value at the completion of a vigorous boil. At General Electric, a minimum number of heats was analyzed for nitrogen with an average result of 0.0052 per cent.

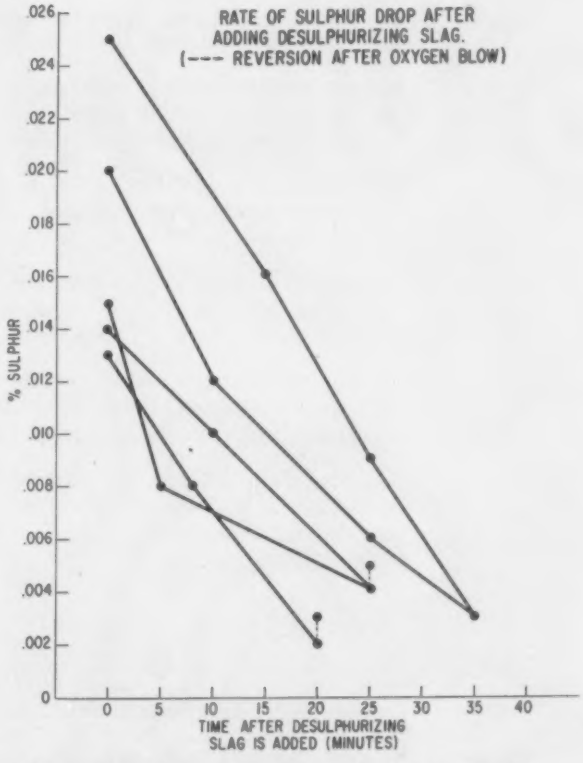
To compete in today's aerospace technology, the steel foundry industry must produce engineered structures with over-all integrity and previously unattained standards of excellence. Technological advances to give better understanding to the physics of solidification, heat and mass flow during solidification, thermodynamics and kinetics of melting and refining, and the applications of these principles to practice, are the teachings the steel foundry industry must follow. Steels with lower impurity contents are a great stride in this direction.

Chemical and Mechanical Properties of Typical Heat

C	0.17%	Tensile Strength	60,000 psi (4219 kgs/sq.cm.)
S	0.003%	Yield Strength	38,000 psi (3672 kgs/sq.cm.)
P	0.019%	Reduction of Area	52.6%
Mn	0.56%	Elongation	37.0%
Si	0.26%		



Polished and etched specimen (500X), showing the type of sulphide inclusion present. The number of sulphides was extremely small and no sulphides of other shapes were observed. It is concluded from the deoxidation practice used, that the sulphide inclusions were of type III category.



Rate of sulphur drop of five typical heats after addition of the desulphurizing slag. Shown are the length of time required to bring the melt to proper temperature and the slag to the proper fluidity and equilibrium. In two heats there was a sulphur reversion after an oxygen blow.

AFS New Technology-1961

July Contents

Quality control can exist only when sand samples are truly representative. Sampling is equally as important as testing. Steps are suggested to include a complete cross-section of the nature and condition of the sand. 49

A French technique using thermosetting binders and hot core boxes produces precision castings at lower costs. Varying proportions of sugar and urea formaldehyde are used as binders in the process. 55

Ductile iron graphite form classification has been simplified through graphite type and size charts. These are suggested as interim measures until international or American proposals are accepted. 65

Resistance to abrasion and heavy impact shock provided by compounded polyurethanes give patternmakers a new tool in high production equipment. 72

Higher iron temperature and faster melting rates with less coke are being obtained by West German foundries with a special calcium carbide. Additional benefits are also reported for this technique. 75

Adaptation of experimental work to practice provides an efficient gating system for bronze castings made in shell molds. One important feature is the cutting of the rejection rate to less than three per cent. 81

Use of carbon sand as a molding medium is credited with superior surface finish and grain structure in gray iron, bronze, and aluminum castings. Other advantages accure from its inert nature and low thermal expansion. 88

Quality must be cast into a part. An analysis of short comings, with an analysis of causes and suggested remedies, aids aluminum die casters in their battle for obtaining higher mechanical properties. 96

Gas slag defects have long plagued malleable foundries but can be controlled at the ladles. A seven-point program is recommended for eliminating or minimizing this common defect. 108

Here are 64 more pages of New Technology—selected breakthroughs in the metalcasting field which appear exclusively in MODERN CASTINGS in 1961.

Interpretive summaries of all New Technology for 1961 appeared in the May issue (pages 69 to 84). These nine articles are published for the first time since their presentation in San Francisco at the 65th Castings Congress.

These breakthroughs are the most important new technological advances in metalcasting. They were authenticated as new contributions by a 600-man technological committee guided by a member of the editorial and professional staff, S. C. Massari, AFS Technical Director. The section is edited by M. C. Hansen.

All New Technology is further evaluated by MODERN CASTINGS editors for their significance as practical tools today. Written comments or criticisms of these articles will be included in the 1961 AFS TRANSACTIONS if submitted before September 15, to AFS Headquarters, Golf & Wolf Rds., Des Plaines, Ill.

SAMPLING OF SAND

AFS Grading, Fineness and Distribution Committee
(8-F) Report

ABSTRACT

The importance of sampling and controlling raw materials is increasing as the foundries modernize. Due to frequent requests for more information on sampling, Committee 8-F of AFS Sand Division and the Grading and Fineness Committee of the N.I.S.A. conducted a survey of sampling techniques and the probable error that can be expected in the sieve tests.

The survey showed that there is no universal, simple method of sampling. Each laboratory, foundry or mining operation has its own special technique or method which is satisfactory for its own conditions but not satisfactory for everyone. Nonmetallics will segregate according to grain distribution, density, moisture content and method of loading. The most uniform sample can be taken while the material is being loaded for shipment.

INTRODUCTION

In the casting industry, as well as in other industries, trained technicians run the tests, but untrained men from the unloading crew often get the samples of raw materials. Sampling is equally as important as the testing, and every precaution should be taken to obtain samples that show the true nature and condition of the materials they represent. Test results are valuable only when the tests are performed on a sample that is representative. Sampling and testing require practical experience and thought, to be carried out efficiently.

Samples are taken for two purposes:

1. To represent as nearly as possible an average of the materials sampled and to know the variation that is normally expected.
2. To subject materials to additional tests for controlling or improving methods and products.

Often a sample and a specimen are considered to be the same, but this is an error. A representative sample is a definite quantitative representative amount, containing the same proportions of each essential constituent. A specimen is a portion that contains a noticeable amount of each essential constituent of the mass from which it is taken, but it is intended only as a qualitative representative amount. The eye cannot accurately detect various amounts of materials so it can not distinguish unlikeness. A test is the only way to judge a shipment.

BULK SAMPLING OF DAMP MATERIALS

Sampling of materials is an important phase of laboratory testing. There are various methods and procedures for getting samples and each one should have some good points. It is most important that the same method of procedure be followed for all samples. Sampling of damp sand and/or a clay bearing sand is not as difficult as a clay free, dry sand. If difficulties are found in sampling sand due to excess segregation, it is suggested that the shippers sample and test data be used.

There are many ways of taking samples from various types of equipment. It is recommended that open cars, covered hoppers, and trucks be sampled as shown in Fig. 1.

At least ten equal increments of at least one lb each shall be taken from various equally spaced places on the car or truck, as shown in Fig. 1. An excavation of about one ft in depth shall be made at each sampling place or point, and the sample shall be taken from the bottom of the excavation.

Commercially available samplers are designed for this purpose. Some of the types available are shown in Fig. 3.

A box car of sand is usually loaded on both ends leaving the doorways clear. Because of the motion of the car enroute the material is usually flat or even throughout the car. When this happens the material in the car is sampled with the same procedure as shown in Fig. 1. If the material is still in a heap or piled on both sides of the car, at least six places or points shall be sampled from each end; about one lb from each location (Fig. 2).

BAG SAMPLING

A sample from a bag shipment shall be taken with as much accuracy as possible. The number of bags to be sampled shall be the cube root of the number of bags in the shipment. At least one lb shall be taken

Grading, Fineness and Distribution Committee (8-F): T. W. Seaton, *Chairman*, J. G. Smillie, *Vice Chairman*, R. W. Bennett, W. D. Chadwick, C. F. Daly, L. F. Dennie, R. Dietert, G. DiSylvestro, H. S. Fagan, F. P. Goettman, W. L. Hemingway, W. Mahlig, L. Marinelli, R. E. Morey, G. Nestor, J. A. Schumann, E. W. Smith, N. J. Stickney, W. C. Swanson, T. A. Tarquinio, L. E. Taylor, S. Walker and S. A. Wick.

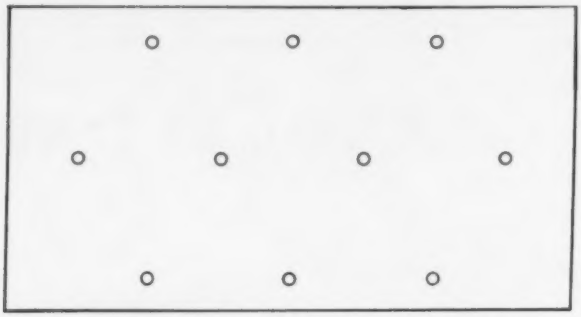


Fig. 1 — Open cars, covered hoppers and trucks of sand recommended sampling method. Ten equal increments are taken, about one ft deep.

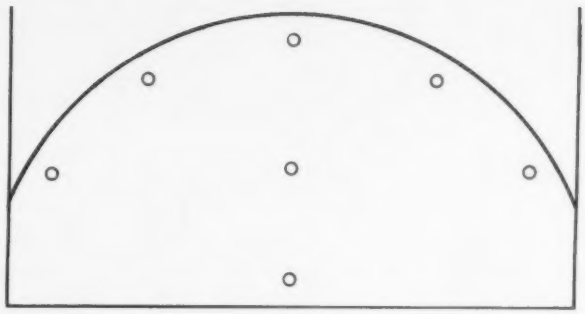


Fig. 2 — If the material is in a heap or piled on both sides of the car, this method is recommended. At least six points are sampled; seven points are shown.

from each bag in such a way that part of the sample be taken below the surface.

If the combined samples are large, they can be reduced in size by the quartering method. Further reduction in size is done with a sand splitter. A sample should always be split to the approximate desired weight. Altering the weight by means of adding or reducing small amounts shall not be done.

Some of the samplers that can be purchased or made are shown in Fig. 3.

SAMPLING AND REPRODUCIBILITY

The problem of sampling damp material is not as great as sampling dry material. One method is to use a 2 in. diameter x 6 ft long tube, thrusting it into the sand in a perpendicular manner and taking the 2 in. core sample from the same locations as shown in Fig. 1.

In order to learn the probable error that can be expected in the sieve test, 20 damp samples and 20 dry samples were sent to 20 laboratories for testing. Each laboratory received a different bag containing approximately 2 lb of damp silica sand. These bags were marked 1, 2, 3, etc. Each laboratory also received a bottle containing approximately 50 grams of dry silica sand. These bottles were marked A-1, A-2, A-3, A-4, B-1, B-2, etc. Bottle *A* went to four laboratories, bottle *B* went to four laboratories, etc.

The silica sand selected was washed and graded, and in the damp condition. The sand was reduced in size with a sand splitter having nine ½-in. slots on each side, Fig. 4.

Approximately 80 lb of damp silica sand was split five times until there were 32 samples of approximately 2 lb each. These samples were put into bags and sent to 20 committee members. The members were instructed to dry sample in an oven, reduce sand to approximately 50 grams, and run sieve test.

Two damp sand samples from above group were mixed together and dried in an oven at 220 F for 2 hr. The dry sand was split five times with a sand splitter, until each sample was approximately 50 grams. Five 50 gram samples were selected and put into small glass bottles. Each bottle was sent to four laboratories. The personnel of the committee was instructed to put the contents of the bottle into their sieves without trying to reduce the sample to a certain weight. After sieving and weighing, the weights were computed on the basis of 100 grams. This procedure eliminated sampling error.

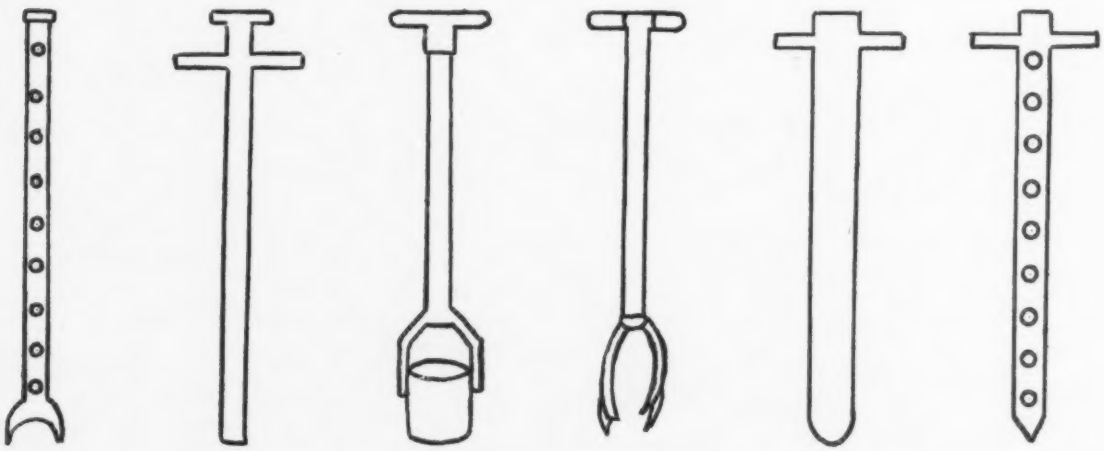


Fig. 3 — Some of the different shaped sand samplers which are available.

Fig. 4 — Sand was reduced in size with a sand splitter having nine ½-in. slots on each side.

DISCUSSION OF THE DATA

Charts 1, 2 and 3 show the sieve test data collected from the 20 participating laboratories.

The data listed under columns numbered 1, 2, 3, 4, etc., represents data on the 2 lb samples.

The data listed under 1-A, 2-A, 3-A, 4-A, 1-B, 2-B, 3-B, etc., are data collected on the samples of approximately 50 grams. All of the samples showing the letter *A* after them represent tests by four laboratories on the same 50 gram sample. The same is true of the B's, C's, D's and G's. In other words, four different laboratories ran the same 50 gram sample.

The type of vibrating equipment used by the various laboratories is shown under their reported data. Sieving time is indicated, the type of sieves on which the tests were run is shown and the method of preparing the smaller sample from the 2 lb sample is shown.

Chart 4 is a summation of the data, and is broken down to show the range of the tests and the ranges with respect to the type of sifting device employed.

Tables *A* and *B* show the data recorded in charts 1, 2 and 3, as a cumulative analysis for all of the tests. The high and low ranges for the damp samples (2 lb) are shown at the bottom of Table *A*. The high and low ranges for the dry samples (50 gram) are shown at the bottom of Table *B*. The averages for both dry and damp samples are also shown.

The cumulative data was then plotted on semi-log graph paper in order to obtain additional information. The cumulative plot enables the "sorting coefficient" and skewness of a sand to be determined and compared with other sands.

In order to calculate the sorting coefficient and skewness of a sand, the 25 per cent quartile (Q_1), Median (M) and 75 per cent quartile (Q_3) must be determined.

Figure 5 shows how these figures are obtained. It shows the cumulative plot of the average sieve analysis of the 20 damp samples. At the bottom are listed the U.S. Series Sieves used to run the sieve analysis. They are plotted on the basis of sieve opening size in microns. At the top of the graph is shown the corresponding micron sizes. The vertical plot is the cumulative per cent from 0 to 100 per cent.

The 25 per cent Quartile (Q_1) is that point at which the 25 per cent retained line intersects the curve and is then dropped vertically to meet the base and the value is recorded in microns. The median (M) is obtained by extending the 50 per cent retained line in the same manner. The 75 per cent Quartile (Q_3) is obtained by extending the 75 per cent line.

The sorting coefficient (S_o) is a measure of the distribution, and is obtained from the formula:

$$S_o = \sqrt{\frac{Q_1}{Q_3}}$$

Where particles are all of the same size, the sorting coefficient would be 1.0. As distribution broad-

CHART 1 — SIEVE TESTS ON DAMP AND DRY SAMPLES

U.S. No.	Microns	1	1A	2	2A	3	3A	4	4A	5	5B	6	6B	7	7B
6	3360														
12	1680														
20	840									0.02	0.02				
30	590			0.2	0.2	0.1	0.2	0.1		0.05	0.06	Tr	Tr		0.2
40	420	2.0	1.7	2.0	1.9	1.7	1.8	1.9	2.0	2.02	1.84	2.4	1.9	1.9	1.6
50	297	14.0	13.4	12.6	12.8	12.7	13.2	13.8	15.3	12.58	12.25	13.0	13.1	13.5	12.6
70	210	37.0	34.9	32.3	32.4	31.8	31.2	35.0	35.4	33.14	31.73	35.8	36.5	38.7	35.6
100	149	37.0	41.3	41.7	41.1	41.3	41.0	40.6	36.4	40.55	41.51	37.2	36.8	36.6	40.0
140	105	8.2	7.2	10.2	10.5	11.1	11.1	7.2	9.4	10.46	11.05	10.0	10.2	8.4	9.0
200	74	1.2	1.2	1.0	1.0	1.1	1.4	1.0	1.0	1.00	1.21	1.4	1.1	0.7	0.8
270	53	0.1	0.2	0.1	0.2	0.1		0.2	0.1	0.09	0.13	0.1	0.2		
Pan		0.1								0.05	0.10	0.1	0.2	0.2	0.2
Vibrator		Rotate-Tap		Rotate-Tap		Rotate-Tap		Rotate-Tap		Rotate-Tap		Rotate-Tap		Rotate-Tap	
Time		15 min		—		15 min		15 min		—		15 min		15 Min	
Sieves		Certified		Standard		Standard		Certified		Matched		—		—	
Splitter		Tyler		Sand		Sand		Tyler		Tyler		Mechanical		—	

CHART 2 — SIEVE TESTS ON DAMP AND DRY SAMPLES

U.S. No.	Microns	8	8B	9	9D	10	10D	11	11D	12	12D	13	13G	14	14G
6	3360														
12	1680														
20	840											0.02			
30	590		0.2	0.08	0.04	Tr	Tr	0.10	0.05	0.04	—	0.03	0.06	0.2	0.2
40	420	2.0	1.3	2.32	2.20	2.2	2.2	1.75	1.80	2.22	—	2.63	2.50	2.0	2.9
50	297	13.0	12.6	15.26	15.22	12.2	12.2	13.55	13.65	14.05	—	14.75	14.34	15.0	16.5
70	210	38.2	36.1	34.78	34.33	35.0	34.8	33.60	33.70	41.65	—	44.32	43.10	38.4	38.1
100	149	38.2	40.7	34.38	38.32	40.8	39.6	37.60	37.80	32.24	—	31.45	32.80	34.4	33.9
140	105	7.2	7.6	7.64	8.02	8.8	8.2	12.00	11.30	8.60	—	5.60	6.00	8.8	7.5
200	74	1.0	1.3	1.30	1.56	0.8	1.6	1.10	1.30	1.12	—	1.00	1.00	1.0	0.7
270	53		0.2	0.16	0.22	0.1	0.1	0.10	0.20	0.04	—	0.18	0.06	0.1	0.1
Pan				0.08	0.08	0.1	0.1	0.20	0.20	Tr	—	0.02	0.14	0.1	0.1
Vibrator		Rotate-Tap		Rotate-Tap		Rotate-Tap		Rotate-Tap		Coombs		Coombs (No tappers)		Coombs	
Time		—		15 min		15 min		—		15 min		15 min		—	
Sieves		—		Standard		Standard		Standard		Standard		Standard		Standard	
Splitter		Jones		Quartered		Simple		Tyler		Rolled & Quartered		—		Quartered	

CHART 3 — SIEVE TESTS ON DAMP AND DRY SAMPLES

U.S. No.	Microns	15	15G	16	16G	17	17C	18	18C	19	19C	20	20C
6	3360												
12	1680												
20	840	0.01											
30	590	0.06	0.042	0.1	0.1			0.2		Tr		0.1	Tr
40	420	2.00	2.184	1.6	1.9	2.2	2.0	1.6	2.0	1.8	1.9	1.8	1.9
50	297	13.26	14.018	12.0	13.3	13.6	11.8	13.4	14.0	11.0	11.5	10.8	12.2
70	210	37.09	36.419	38.1	39.5	37.4	37.2	32.4	32.6	31.7	34.5	37.9	37.3
100	149	37.91	37.613	38.8	37.2	38.6	39.6	41.6	41.2	43.8	42.0	38.8	38.8
140	105	8.86	8.812	8.3	6.9	7.2	8.0	9.6	9.2	10.0	8.7	9.2	8.6
200	74	0.71	0.761	0.8	0.8	1.0	1.2	0.8	0.8	1.4	1.2	0.9	0.7
270	53	0.05	0.029	0.2	0.2		0.2	0.2	0.2	0.2	0.2	0.2	0.5
Pan		0.05	0.122	0.1	0.1		Tr	0.2		Tr		0.1	—
Vibrator		Coombs (Tappers on all sieves)		—	—	Rotate-Tap		Rotate-Tap		Rotate-Tap		Rotate-Tap	Rotate-Tap
Time		15 min		—	—	—		—		15 min		15 min	15 min
Sieves		Standard		Master		—		Standard		Standard		—	—
Splitter						Jones		Quartered		Jones			Quartered

(Data for Fig. 5)
Sieve Test

U.S. Series Sieve No.	Microns	Cumulative %
6	3360	
12	1680	
20	840	
30	590	
40	420	2.1
50	297	15.3
70	210	51.6
100	149	89.9
140	105	98.3
200	74	99.8
270	53	99.9
Pan	—	

Q_1	M	Q_3	S_o	S_k
261	210	170	1.241	1.006

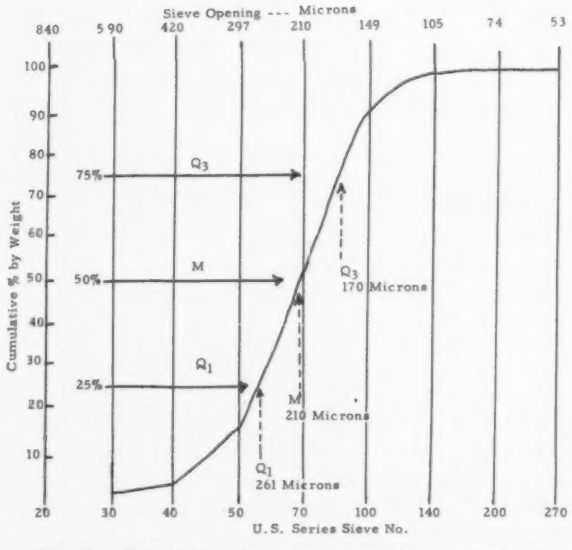


Fig. 5 — Cumulative data of average sieve analysis of 20 damp samples.

TABLE A — CUMULATIVE RESULTS — DAMP SAMPLES

Sample	6	12	20	30	40	50	70	100	140	200	270	Pan
1					2.0	16.0	53.0	90.4	98.6	99.8	99.9	100.0
2				0.2	2.2	14.8	47.1	88.8	99.0	100.0	100.0	100.0
3				0.1	1.8	14.5	46.3	87.6	98.7	99.8	99.9	100.0
4				0.1	2.0	15.8	50.8	91.4	98.6	99.6	99.8	100.0
Avg. 1-4				0.1	2.0	15.3	49.3	89.6	98.7	99.8	99.9	100.0
5				0.1	2.1	14.7	47.8	88.4	98.8	99.8	99.9	100.0
6					2.4	15.4	51.2	88.4	98.4	99.8	99.9	100.0
7					1.9	15.4	54.1	90.7	99.1	99.8	99.8	100.0
8					2.0	15.0	53.2	91.4	98.6	99.6	99.8	100.0
Avg. 5-8					2.1	15.1	51.6	89.7	98.7	99.8	99.9	100.0
9				0.1	2.5	18.4	54.6	90.5	99.5	99.8	99.9	100.0
10					2.2	14.4	49.4	90.2	99.0	99.8	99.9	100.0
11				0.1	1.8	15.4	49.0	86.6	98.6	99.7	99.8	100.0
12					2.3	16.3	58.0	90.2	98.8	99.9	100.0	100.0
Avg. 9-12					2.2	16.1	52.7	89.4	99.0	99.8	99.9	100.0
13				0.1	2.7	17.4	61.8	93.2	98.8	99.8	100.0	100.0
14				0.2	2.2	17.2	55.6	90.0	98.8	99.8	99.9	100.0
15				0.1	2.1	15.3	52.4	90.3	99.2	99.9	99.9	100.0
16				0.1	1.7	13.7	51.8	90.6	98.9	99.7	99.9	100.0
Avg. 13-16				0.1	2.2	15.9	55.4	91.0	98.9	99.8	99.9	100.0
17					2.2	15.8	53.2	91.8	99.0	100.0	100.0	100.0
18				0.2	1.8	15.2	47.6	89.2	98.8	99.6	99.8	100.0
19					1.8	12.8	44.5	88.3	98.3	99.7	99.9	100.0
20				0.1	1.9	12.7	50.6	89.4	98.8	99.7	99.9	100.0
Avg. 17-20				0.1	1.9	14.1	49.0	89.7	98.7	99.8	99.9	100.0
Avg. of 20 samples					2.1	15.3	51.6	89.9	98.8	99.8	99.9	100.0
Range — High					2.7	18.4	61.8	93.2	99.5	100.0	100.0	100.0
Range — Low					1.7	12.7	44.5	86.6	98.3	99.6	99.8	100.0

TABLE B — CUMULATIVE RESULTS — DRY SAMPLES

Sample	6	12	20	30	40	50	70	100	140	200	270	Pan
1A					1.7	15.1	50.0	91.3	98.5	99.7	99.9	100.0
2A				0.2	2.1	14.9	47.3	88.4	98.9	99.9	100.1	100.1
3A				0.2	2.0	15.2	46.4	87.4	98.5	99.9	100.0	100.0
4A					2.0	17.3	52.7	89.1	98.5	99.5	99.6	100.0
Avg. 1A-4A					1.9	15.6	49.1	89.0	98.6	99.8	99.9	100.0
5B				0.1	1.9	14.2	45.9	87.4	98.5	99.7	99.8	99.9
6B					1.9	15.0	51.5	88.3	98.5	99.6	99.8	100.0
7B				0.2	1.8	14.4	50.0	90.0	99.0	99.8	99.8	100.0
8B				0.2	1.5	14.1	50.2	90.9	98.5	99.8	100.0	100.0
Avg. 5B-8B				0.1	1.8	14.4	49.4	89.2	98.6	99.7	99.8	100.0
9D					2.2	17.5	51.8	90.1	98.1	99.7	99.9	100.0
10D					2.2	14.4	49.2	88.8	97.0	98.6	98.7	98.8
11D					1.8	15.5	49.2	87.0	98.3	99.6	99.8	100.0
12D												
Avg. 9D-11D					2.1	15.8	50.1	88.6	97.8	99.3	99.5	99.6
13G				0.1	2.6	16.9	60.0	92.8	98.8	99.8	99.9	100.0
14G					3.0	19.6	57.7	91.6	99.1	99.8	99.9	100.0
15G					2.2	16.2	52.7	90.3	99.1	99.8	99.9	100.0
16G				0.1	2.0	15.3	54.8	92.0	98.9	99.7	99.9	100.0
Avg. 13G-16G					2.4	17.0	56.3	91.7	99.0	99.8	99.9	100.0
17C					2.0	13.8	51.0	90.6	98.6	99.8	100.0	100.0
18C					2.0	16.0	48.6	89.8	99.0	99.8	100.0	100.0
19C					1.9	13.4	47.9	89.9	98.6	99.8	100.0	100.0
20C					1.9	14.1	51.4	90.2	98.8	99.5	100.0	100.0
Avg. 17C-20C					2.0	14.3	49.7	90.1	98.8	99.7	100.0	100.0
Avg. of 19 samples					2.0	15.3	51.0	89.8	98.6	99.7	99.8	99.9
Range — High					3.0	19.6	60.0	92.8	99.1	99.9	100.1	100.1
Range — Low					1.5	13.4	45.9	87.0	97.0	98.6	98.7	98.8

CHART 4 — RESULTS OF SIEVE TESTS

U.S. Series	Avg. 1 to 20	Avg. all rotate-taps	Avg. all Coombs	Range all Tests	Range all rotate-taps	Range all Coombs
20	Tr	Tr	Tr	0.0- 0.02	0.0- 0.02	0.0 - 0.02
30	0.1	0.1	0.1	0.0- 0.2	0.0- 0.2	0.03- 0.2
40	2.0	2.0	2.1	1.3- 2.9	1.3- 2.4	1.6 - 2.9
50	13.3	13.2	13.8	10.8-16.5	10.8-15.3	12.0 -16.5
70	36.5	35.6	39.5	31.2-44.3	31.2-41.7	36.4 -44.3
100	37.9	38.5	35.6	31.5-43.8	32.2-43.8	31.5 -38.8
140	8.8	9.1	7.9	5.6-12.0	7.2-12.0	5.6 - 8.9
200	1.0	1.0	0.9	0.7- 1.6	0.7- 1.6	0.7 - 1.0
270	0.1	0.1	0.1	0.0- 0.2	0.0- 0.2	0.03- 0.2
Pan	0.1	Tr	Tr	0.0- 0.2	0.0- 0.2	0.02- 0.1

TABLE C — GRAPHIC RESULTS FOR DAMP SAND

Sample	Q_1	M	Q_3	S_o	S_k
1	269	215	174	1.242	1.012
2	260	206	169	1.240	1.034
3	257	203	167	1.241	1.027
4	265	212	173	1.238	1.020
Avg. 1-4	263	209	171	1.240	1.023
5	260	206	168	1.244	1.029
6	267	212	172	1.247	1.022
7	269	217	177	1.242	1.010
8	268	216	178	1.227	1.022
Avg. 5-8	266	213	174	1.240	1.021
9	276	218	174	1.259	1.010
10	261	209	172	1.232	1.032
11	264	209	168	1.252	1.015
12	275	224	180	1.237	0.987
Avg. 9-12	269	215	174	1.245	1.011
13	279	230	186	1.223	0.981
14	273	219	176	1.245	1.001
15	268	213	174	1.241	1.027
16	262	212	174	1.228	1.015
Avg. 13-16	271	219	178	1.234	1.008
17	269	215	177	1.232	1.029
18	258	205	169	1.235	1.037
19	251	200	166	1.230	1.041
20	260	211	173	1.225	1.011
Avg. 17-20	260	208	171	1.231	1.029
Avg. 1-20	266	213	173	1.238	1.018
Range—High	279	230	186	1.259	1.041
Range—Low	251	200	166	1.223	0.981

ens, the sorting coefficient increases. Most sands will fall between 1.14 and 2.50.

Skewness coefficient (S_k) is a measure of the slope of a curve, and is calculated from the formula:

$$S_k = \frac{Q_1 \, Q_3}{M^2}$$

Tables *C* and *D* show the figures obtained from the graph and S_o and S_k for all the sands tested. The average values are shown and the high and low range is shown.

CONCLUSIONS

The data obtained for this work were obtained under what would be considered ideal conditions. Samples were prepared with extreme care and sieve tests were run under the most desirable conditions.

These facts developed as a result of this study:

1. Exact duplication of sieve tests between different laboratories under the most closely controlled conditions is difficult, if not impossible.

TABLE D — GRAPHIC RESULTS FOR DRY SAND

Sample	Q_1	M	Q_3	S_o	S_k
1A	262	210	177	1.218	1.050
2A	257	205	171	1.227	1.045
3A	255	203	167	1.235	1.033
4A	268	214	174	1.241	1.018
5B	260	203	166	1.251	1.045
6B	268	212	170	1.255	1.014
7B	265	210	170	1.249	1.020
8B	263	210	170	1.238	1.014
9D	270	212	173	1.250	1.038
10D	261	209	171	1.235	1.021
11D	262	208	168	1.250	1.017
12D					
13G	274	227	184	1.221	0.978
14G	278	223	180	1.242	1.005
15G	268	214	174	1.241	1.017
16G	268	218	179	1.223	1.009
17C	261	212	174	1.225	1.010
18C	262	207	170	1.241	1.039
19C	257	206	170	1.230	1.028
20C	261	212	174	1.225	1.009
Total Avg.	264	211	172	1.237	1.022
Range—High	278	227	184	1.255	1.050
Range—Low	255	203	166	1.218	0.978

2. The inability to obtain duplication of tests must of necessity be taken into consideration whenever specifications for sand are discussed.
3. Extreme care in sampling is a must. Careless sampling can only result in misleading and erroneous information.
4. Sieving efficiency for various types of shakers is dependent on time. The "end-point" of sieving or the reproducibility varies with each type of shaker.

These recommendations are made by this committee as a result of this study:

1. Samples should be obtained by the methods presented to insure obtaining representative samples.
2. A sample splitter should be used to split the sample down to the approximate test sample size. Never add to or remove from the split sample to obtain a sample of a definite weight. This will destroy the value of the sample.
3. It is necessary to weigh only to the nearest tenth of a gram.
4. If an analysis does not meet expected results or specifications, obtain another sample. Do not retest the same sample.
5. Better accuracy of weighing can be obtained by cumulative weighing than by weighing material retained on individual sieves separately.
6. The variations in sieve tests shown in this report are what can be normally expected under the most closely controlled conditions.
7. It can reasonably be expected that there will be differences in tests run by producers and consumers on shipments of raw materials. These variations should be determined and used as a basis for setting up specifications.
8. It is suggested that consumers accept the samples obtained at point of production as being representative of the shipment and where possible, accept suppliers test data.

CORE PRODUCTION IN HOT CORE BOXES

by Philippe Jasson

ABSTRACT

It is now over three years that core production in hot boxes has been in operation at the author's company for mass production of automobile parts. Different techniques to those at present being developed in the United States, were elaborated. In this report, the company's realizations in this field are described.

INTRODUCTION

As early as the beginning of 1956, the author's company was called upon to define what is now called core production in hot boxes, and it is of interest to recall the reasons which brought the company to elaborate upon this process.

The foundryman's ambition is to improve the quality of his moldings while reducing his costs. In automobile foundry, owing to the size of the cored castings, the cost of producing the cores has a considerable influence on the cost price of the molded part. However, it can easily be proved that, in the standard core production, the cost price of a core depends essentially on the cost of man power employed in accessory operations such as – preparation of wires, fitting of dryer, loading and unloading drying oven, finishing and grinding the cores to size and checking and measuring before molding again.

These operations are rendered necessary owing to distortions which occur while stripping the core or during curing. Hardening the core in the box therefore appears to be the rational method of obtaining core precision and to reduce the cost thereof, and this by the suppression of the accessory operations. It is to be noted, however, that all the new processes of core production, which have appeared in recent years, apply the method of hardening the sand in contact with the core box. Whether it be shell molding, silicate molding carbon dioxide hardened, air set sand molding, and even some investment molding techniques, the mass of sand is hardened before being separated from the pattern.

However, one must agree that each of these processes, considered separately, has its advantages and its drawbacks, and the company has endeavored to create a process which would be the synthesis of modern tendencies, while maintaining, however, a certain number of imperative conditions which are well founded, as proved by traditional methods. In particular, the company has tried to retain:

1. The production of solid cores, the body of which is capable of supporting the outer parts bearing the stress of the metal when casting. In fact, thin walled cores or parts of molds must generally be reinforced, excepting in the case of small castings, by sand packing, shot or gravel, in order to restore assemblies capable of resisting without distortion the pressure of melted metal.
2. The production of a core equally hardened on all its faces. It is a fact that it is not only the core part in contact with the metal which is of importance in the precision of an assembly. The remainder of the core serves either as a bearing surface or as a support, and in consequence, has a large part in this precision.
3. The production of a core having a high superficial hardness, that is having a similar strength to that of the conventional oil core, if not higher. This high strength (estimated at the minimum at 250 psi tensile strength) is in fact necessary in cases of cores of small section, submitted to heavy stresses in the course of remolding manipulations and during casting. Such cohesion values are not obtained with silicate sands, CO_2 hardened. Their specifications after hardening are much nearer those of dried molding sands than those of oil cores.
4. The use of organic binders. The advantages of which over mineral binders are well known – low resistance to contraction of the cooling metals, easy shake out, no sand vitrification giving an improved finish to the moldings.

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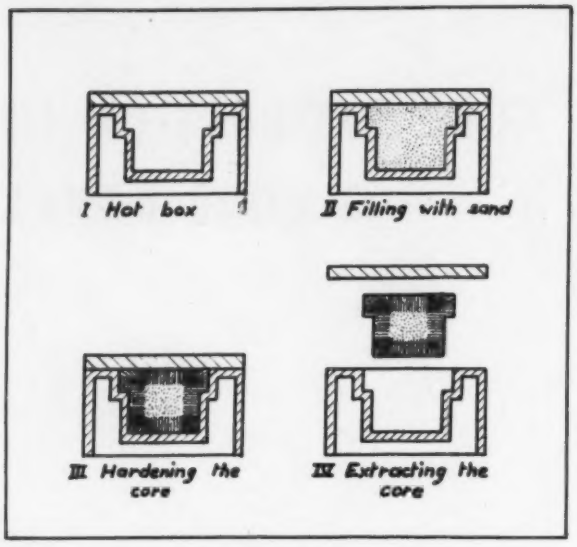


Fig. 1 — Principle of the hot box core process.

5. The use of a liquid binder. This notion is essential for questions of performance. A liquid binder easily enrobes the grains of sand in a uniform film; furthermore, it gives to the mixture a low green strength, thus allowing ramming operations by the usual methods — blowing, projection, squeeze, vibration.
6. Hardening in the box in the quickest time possible (2 min max.) compatible with the rational use of pattern and mass production in automobile foundries. This speed of execution is not obtained with the air set sand technique which requires immobilizing patterns sometimes for several hours.

HOT CORE BOX PRINCIPLE

Under the circumstances, the ideal would have been to use an organic binder, capable of instantaneous hardening when cold following a similar reaction to that of carbon dioxide on sodium silicate. Such a binder not having been placed at the foundryman's disposal at least for the present by the chemical industry, the only range of suitable products, practically, remain the thermosetting group, i.e., products which are liquid at ambient temperature and which under the influence of an increased temperature are capable of becoming a three dimensional molecular network which render them solid and nonfusable. If it is added that heat transmission phenomenons are carried out much more easily if the source of the heat is a solid instead of a gas, which means that a mass of sand heats up much more rapidly when in contact with a hot solid, than when placed in the midst of a hot gas, one arrives quite naturally at defining the principle of core production in hot boxes.

The principle of this process, detailed in Fig. 1 is:

a) A core box (I) pre-heated to a certain temperature, is filled with mixture of sand and liquid thermosetting binder (II).
b) In contact with the hot box, the sand sets through the polymerizing of the binder, to a certain depth which varies according to the temperature of the box and the curing time (III).
c) From the box a core, which can be considered as finished, is then extracted, as it has acquired its final hardness (IV). The box is thus freed for a further operation.

One must insist on the necessity of baking in an entirely closed box, so as to obtain the hardening of the entire surface of the core. The closing of the box can take place either before or after the filling operation according to the ramming process used. Furthermore, one will note that a core obtained through this process will appear as a compact mass hardened on all its faces, the center being in some state or other, hardened or not by the polymerization of the binder.

BINDER CHOICE

It must be understood, the carrying out of such a process requires for the binder supplementary specifications which further reduce the possible choice in the thermosetting group:

1. The baking speed. All thermosetting binders do not polymerize at the same speed. In practice, the most interesting binders are those which are capable of hardening at the lowest temperature.
2. Absence of thermoplasticity in the range of temperatures likely to be attained with the hot box contact, otherwise there is a risk of distortion when stripping, thus destroying the advantages inherent to hardening in the box.
3. The price. As the process produces solid cores, the cost price of the prepared sand should be of the same order as that of conventional sands bonded by cereals and oil.

Before this assembly of properties, the company was obliged to eliminate the following thermohardenables:

a) siccative oils, as their hardening is slow and furthermore they are thermoplastic.
b) polyesters and epoxides, the cost of which is extremely high in France.
c) phenoplasts, also expensive in France, although there are certainly possibilities in the direction of certain solutions or aqueous emulsions.

Finally, only two categories of products remained, corresponding to the general characteristics stated. On the one hand there were the binders derived from sugar. Particularly cheap, those binders are capable of rapid hardening with the addition of appropriate catalysts and their supplyers are apt to supply in regular qualities. On the other hand, the urea-formaldehyde resins. Easily obtainable, also inexpensive and capable of hardening at low temperatures.

But it is equally clear that this list is not complete, as owing to the principle of core production in hot boxes itself, requiring only one fundamental specification, that of quick polymerization under heat effect, a great number of products could be perfected

to suit this process.* However, up to now the company has only used sugar and urea-formaldehyde based binders. These binders give to the sands particular specifications.

SPECIFICATION OF SANDS BOUND BY HOT BOX HARDENABLE BINDERS

From these two groups of binders — sugar and urea-formaldehyde, a range of formulas containing, either only sugar or only urea-formaldehyde, according to the type of production have been developed. However, mainly in use are mixed formulas containing both sugar and U.F.

The principal specifications of the binders used are:

1. Water contents fairly high from 30 to 50 per cent. Presence of water is indispensable to obtain a liquid binder at normal temperature, but it is inconvenient in the course of the baking of the core, as it must be evaporated.
2. A low viscosity, which enables an easy distribution.
3. The presence of an acid catalyst for polymerizing.

Sand Preparation

The preparation of the sand is an extremely simple operation, as it consists only in distributing a low viscosity binder in the sand and any kind of core sand mixer is likely to suit. Care must be taken only to avoid the excessive evaporation of the water in the binder. The basic sand should be of a high grade of mineralogical purity. The presence of clay, mica and organic matter greatly reduces the dry strength. In practice sands are used, either new or wet reclaimed, of an AFS fineness number between 5 and 105. The agglomeration of olivine and zircon sands is also obtained without difficulty.

Green Properties

Hot box sands present a low green strength. Their compression strength is between 0.3 and 0.6 psi, and are therefore excellent for blowing. Mixtures should be kept away from air, as their contents in water must be calculated with precision. Lack of water reduces hardness after baking, while excess of water slows the baking down.

Bench life depends entirely on the quantity of acid catalyst. Whereas sugar based mixtures have a practically endless preservation, it is not so with those containing urea-formaldehyde. In practice, the quantity of acid catalyst is determined so that a 24 hr preservation is assured.

Dry Properties

Dry properties can be considered under the double point of view of strength and baking speed. On Fig. 2 will be found baking curves for four binders:

a) Linseed oil in the proportion of 0.8 per cent.
b) Formophenolic resin for shell molding in the proportion of 1.5 per cent.

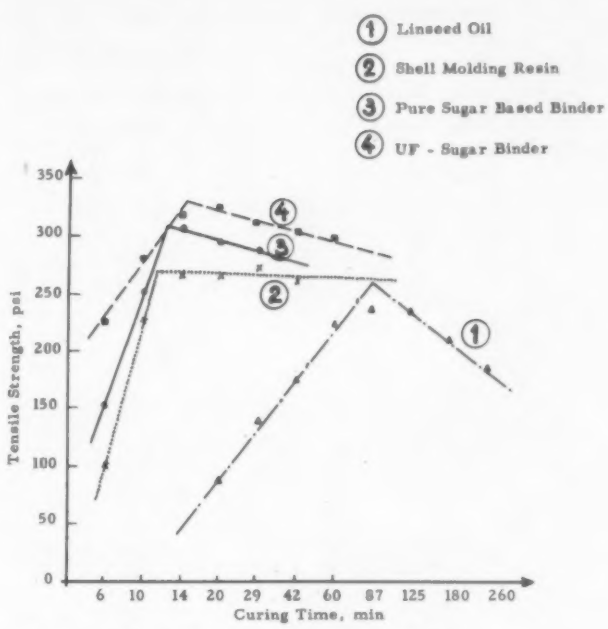


Fig. 2 — Baking curves for four core binders.

c) A sugar base binder for hot boxes in the proportion of 2 per cent.
d) A sugar and U.F. base binder for hot boxes in the proportion of 1.5 per cent.

The first three binders are dried at 225 C (437 F) in an ordinary oven, the UF-sugar mixtures at only 125 C (257 F). It is possible to establish that:

a) From the strength point of view, a tensile strength of 300 psi is obtained with 1.5 per cent of UF-sugar mixture, and of 2 per cent of sugar base binder whereas 260 psi is the maximum with 1.5 per cent shell resin and 8 per cent linseed oil.

The excellent dry strength of the binders, thus made obvious, is due undoubtedly to their excellent distribution in liquid form.

b) From the point of view of baking speed, maximum strength is obtained in 87 min with linseed oil, in 12 or 13 min with the other binders, which show effectively the aptitude of hot box binders to harden quickly, their baking speed being of the same order as that of the phenoplasts widely used with hot pattern contacts. This means that, when using hot boxes, the constitution of the hard crust can take place practically at the same speed as in the case of shell molding. In practice, one can count on obtaining a hard shell of 8-10 mm (0.315 to 0.3937 in.) in thickness in only 2 min baking.

It is also to be noted that the mixture UF-sugar is the quickest and that, only at a temperature of 125 C (257 F), the constitution of the hardened shell is therefore hastened. Finally, the catalyst quantity dosing allows the mixture to continue to harden to the center after the core has been extracted from the box.

*In particular, furanic resins which are being greatly developed just now will not be examined in this report.

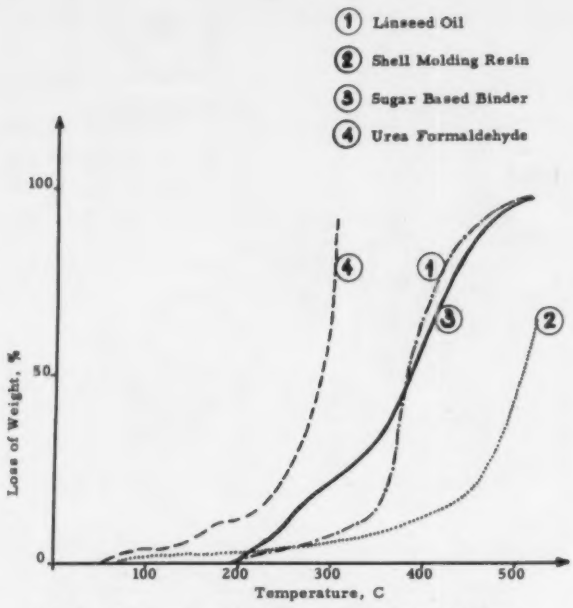


Fig. 3 — Thermal analysis of thermosetting binders.

Behavior While Casting

The diversity of mixtures which are used is precisely due to their varied behavior during the casting. This behavior proceeds from the thermoanalysis curves on Fig. 3. Pure urea-formaldehyde resins deteriorate quickly under heat effect. Their use is therefore reserved for light alloy castings. Sugars have a thermic decomposition curve nearing that of linseed oil. They are, in our range of hot box binders, those with the best heat resistance. They allow the casting of small steel parts, even of low carbon steel. U.F. sugar mixtures show intermediary characteristics and can be used for ferrous metal castings. They are the binders generally used for the casting of parts in gray iron, ductile iron, malleable in small and medium thicknesses, often used in automobile foundry.

Collapsibility and Casting Finish

The shake out of cores obtained in hot boxes does not offer any particular problem. Collapsibility is generally good, whether it be with pure U.F. in aluminum foundry or with UF-sugar mixtures in ferrous foundry. One can even say that one of the most frequent problems is to avoid premature knock out of the cores, which loosens sand. The casting finish is quite acceptable, although in this process, as in the others, it depends essentially on the basic fineness of the grain. Cores produced in coarse sand, and submitted to severe thermal conditions, can easily be dipped in a wash immediately after stripping from the box. The heat stored in the core is generally sufficient to ensure complete drying without further heating.

Sand Formula Cost Prices

The chart, giving cost prices for different sand formulas used at the author's company, shows with precision the economical interest of hot box core production (at least as far as French prices are concerned).

Sand Formula	Cost of binders in N.F. per 100 kg of sand
Sand, linseed oil, dextrin	2.5 to 3
Sand, silicate hardened with CO_2	1.7 to 2.3
Sand, shell molding	10 to 12
Sand, for hot box, UF pure base	3
Sand, for hot box, sugar base	2.75
Sand, for hot box, UF-sugar base	2.50

Thus, it is seen that hot box sand formulas have cost prices which compare quite favorably with those of the other formulas used to produce solid cores — on one hand oil-dextrin, on the other silicate CO It is also to be pointed out that, among the sands liable to hardening in contact with hot patterns, there there is a great difference in price between hot box formulas and those for shell molding.

TECHNOLOGY OF HOT BOX CORE PRODUCTION

Implementing hot box core production consists in carrying out these operations — (a) filling the box with the sand and binder mixture, (b) heating the box to maintain it at a temperature higher than the minimum temperature at which the chosen binder polymerizes and (c) extracting the core from the box. This production cycle having to be carried out at a given rate requires special equipment and boxes.

Filling the Boxes

The ideal way to fill the boxes quickly is, without doubt, by blowing. It can be carried out under excellent conditions owing to the low green bond of the sands for hot boxes and one of the big advantages consists in the possibility to use ordinary blowers. The only really indispensable modification concerns the use of the water cooled blower plate. Where it is not possible to blow the core through a port on the outside of the box, it is necessary that the blow tubes pass through the upper half of the core box while remaining integral with the blower plate. To this end conical nozzles, a type of which appears in Fig. 4 are used.

A washer and spring retainer assembly ensures a certain play in the nozzle as regards the blower plate, and this allows the nozzle to center itself in the core box cover whether hot or cold. Concerning venting when blowing, ordinary slit filters or perforated brass plates are used. The latter system is the better. Finally, it is to be noted that owing to the low green bonding of the sand, the blower holes can be of a small diameter and this allows a correlative reduction in the size of the venting surface. Two models of boxes for blown cores appear on Figs. 5 and 6.

Apart from the blowing, another method is used where greater ramming density is necessary to bring out certain details of the core. By using squeeze and vibration it is possible to obtain ramming densities around 100 lb/cu ft, the lower half of the box having

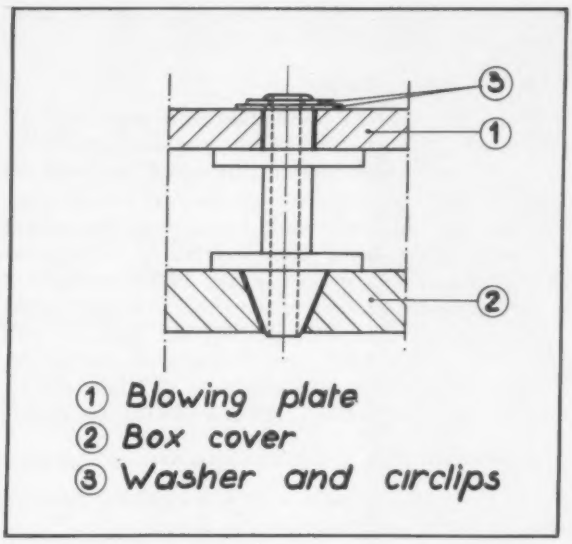


Fig. 4 — Type of blower nozzle.

been filled first by low pressure blowing (20 to 40 psi). This technique is used in particular for the production of flat cores used for stack molding small castings. Figure 7 shows a box built for this type of ramming.

Heating the Boxes

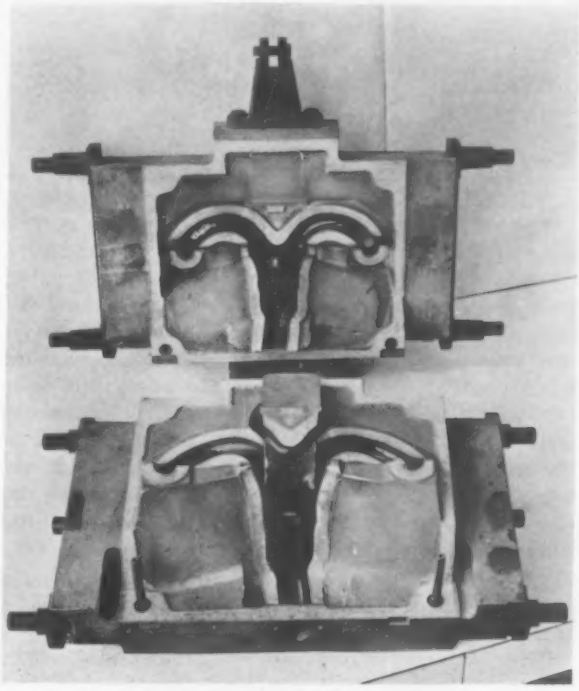
Heating the boxes is one of the important elements in carrying out this process. First of all, one must consider that the introduction of a mass of cold sand into a hot box cools the latter considerably, the sand literally pumping up the calories stored in the box. There is a risk of the box temperature falling below the minimum temperature for the binder polymerization.

As in general one can assume that the heat necessary for the hardening of a solid core is greater than the heat capacity of the pattern, two imperatives result therefrom — (a) use an extremely powerful heating source and (b) apply the heat when the sand is in the box and not before. Under these conditions, the solutions adopted are of two sorts according to the choice of a continuous heat source or of a discontinued one.

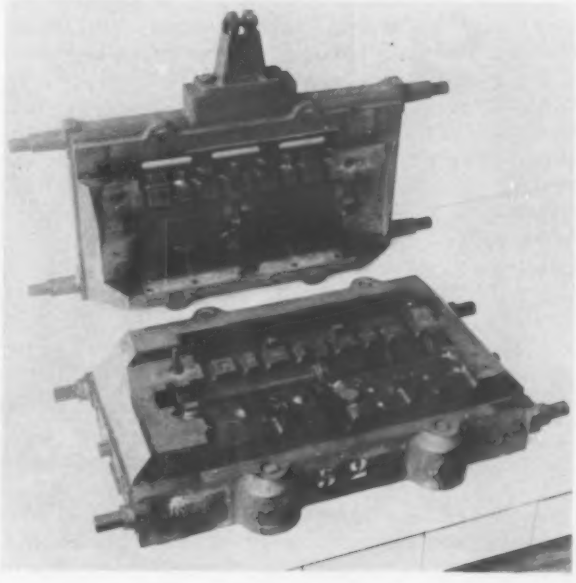
Heating by electric resistance units incorporated in the box. This is the most favored medium, as it permits an easy control, and its efficiency is great but it requires special study for each box. It is often difficult to place resistances on core boxes having numerous accessory equipments such as filters, blow holes, stripper pins. It is necessary to incorporate high power resistances in the core boxes in order to be able to control easily. Up to now, this type of heating has been used only for boxes built in aluminum which has a good coefficient of thermal diffusivity. For core weights under 1.5 kg (3.3 lb) the power installed on each box is from 7 to 8 kw, consumption settling around 5 kw.

Heating by radiation. In particular this refers to the use of gas heated radiating elements. These elements comprise a ceramic surface which the gas combustion heats to 700-800 C (1292-1472 F), and which radiates directly on the outer surface of the boxes. This type of heating, although discontinued has the advantage of allowing the application of important heating power. The model used gives more than 3000 calories (11.900 Btu hr) for an emission surface of 8½x6½-in.

It happens, furthermore, that the use of radiation solves the problem set by core production in hot boxes particularly well, as the object being to transmit heat to the sand, the box plays an intermediary role, trans-



Figs. 5 and 6 — Hot boxes for blown cores.



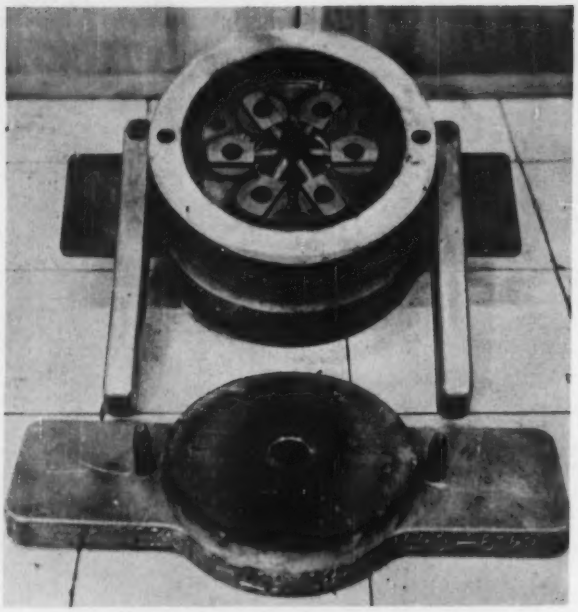


Fig. 7 — Hot boxes designed for ramming by squeeze and vibrations.

ferring by conductibility the calories received by radiation. The drawback in heating by radiation is that it is difficult to control, as the efficiency of an installation depends as much on the transmitter (surface and temperature) as on the receiver (power of absorbtion of the surface) and the distance between the radiant and the box. In practice, control is obtained by varying the gas pressure (this controls the transmitter temperature), and at the same time the distance between the box and the radiant.

In any case, and whatever may be the heating medium employed, baking costs are much below those of conventional core production.

STRIPPING OF THE CORE

It is to be remembered that after hardening, the core even when hot, is a solid extremely hard on all its faces, and has a tendency to bind owing to expansion and contraction respectively of the box and the core. The best method of stripping without doubt is by means of ejectors. Ejectors are used having the shape of valves normally resting on their seats in the bottom of the box. These ejectors slide in a sleeve with plenty of clearance. At their base, an adjusting screw ensures a simultaneous lift. They have no retracting spring, and are brought back into position either by direct control operated by the box cover or by permanent magnets on the stripping machine.

In any case, one must insist on the fact that most of the stripping difficulties are due to defects in the pattern, badly calculated tapers or even undercuts render ejection difficult if not impossible. That is one of the reasons for which hot boxes require utmost care in preparation, if possible by machining, in alloys presenting a high mechanical resistance at high temperatures. From this point of view, notwithstanding unfavorable thermal specifications, cast iron is much superior to aluminum alloys, even the most resistant (for example silicon alloys).

Mass Production Units

The choice of mass production unit types depends both on the baking speed of the core under consideration and on the production rate which has been decided. It has been indicated that the core baking time, even in the most unfavorable case, does not exceed 2 min. If we take into consideration an installation with only one box in service, its hourly production rate is inversely proportional to the core production total length of time, i.e., baking time plus pre and after baking operation time, blowing and stripping.

Thus for example, a baking time of 2 min and 0.6 min for outside time lost makes a production rate of $r = \frac{60}{2 + 0.6} = 23$ cores per hr. This rate is low compared to those obtained with conventional blowers, that can exceed 150 blowings an hour.

As the baking speed can hardly be reduced, owing to the size of the core and the kind of binding selected, one is obliged to set up installations comprising several identical boxes in operation, some in the course of baking while others are being stripped or blown. Thus a rate of 240 an hr will be obtained for cores requiring 1.5 min of baking with $\frac{240 \times 1.5}{60} = 6$ baking boxes. To these 6 boxes, if one adds one being stripped and one being blown, there will be a total of 8 boxes in service at the same time.

All the mass production installations developed at the author's company were studied in view of the production rates to be carried out, they may be classified into 3 types — two station, four station and six or eight station groups.

Two station unit (Fig. 8). This unit comprises two boxes in action; two stripping machines are placed on each side of a blowing machine. The boxes are electrically heated, therefore, by continuous heating. This unit was developed for the production of thin cores, the baking time for which did not exceed double the stripping and filling times. Thus the baking time varying from 40 to 80 sec, production rates arrive at 70 to 120 cores an hr. On this model, a blower plate transfer system permits the simultaneous production of two different cores which can immediately be assembled hot, when taken out of the boxes.

Four station unit. This is the most simple unit developed, it includes a blower, a stripping station and a revolving oven with three heating stations. The oven revolves automatically and is controlled by a time switch adjusted to the desired rate. Four core boxes are in service simultaneously, three of which are being baked, while the fourth passes from the stripping to the blower. Handling of the boxes is entirely manual.

Such an installation manned by two men is capable of a production that can attain 150 cores an hr. Its simple mechanization makes it an ideal means of production for small cores. Figures 9 and 10 show two views of the installation in operation. On Fig. 9 can be seen the blowing operation of a core box with an absolutely standard blower. Figure 10 represents

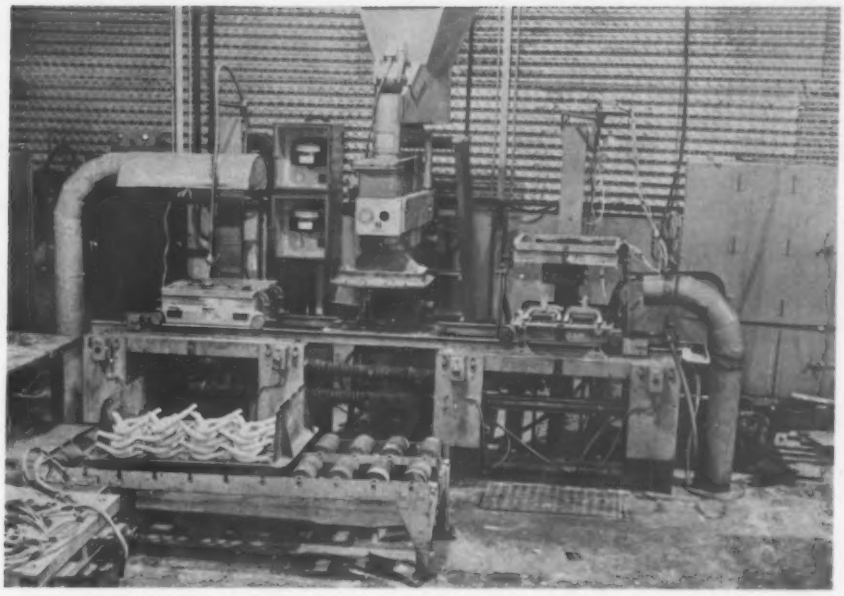


Fig. 8 — Two station production unit.

the manual stripping of a core — the operator utilizes the removable part of the box for extracting.

Six or 8 station units. This machine has a turntable with 6 or 8 stations transferring the boxes successively to the blowing station, the baking station (4 or 6 stations) and the stripping station. It is entirely automatic, and with one operator attains production rates of 240 cores an hr. All the movements of this machine, whether hydraulic or pneumatic are controlled by a program controller.

Figure 11 shows the general view of an 8 station machine. On Fig. 12 can be seen, near view, a stripping station, the core box is open, the core is extrated by ejectors. This 6 or 8 station unit is now in standard production. The rate is adjusted from 180 to 240 cores per hr as needs require. The number of stations in the unit depends entirely on the baking time for the core to be produced, 1.5 min minimum for 8 station machines and one min for the 6 station machines.

As a whole, it can be said that hot box coring can be carried out on a wide variety of production units, as shown by those developed at the author's company. Following the rates required, the degree of automation desired, it is evident that it is possible to use quite simple units with relatively important manual handling or entirely automatic mass production units.

However, these machines have one common feature, that of being relatively light and therefore easily movable. Here is an extremely favorable productivity factor, the redeployment of core shops fitted with hot boxes can be easily carried out as needs require. It is not so with conventional core shops which are necessarily retained by a fixed element, the oven.

FIELD IN WHICH BOX CORING MAY BE USED

The field in which hot box coring can be used is as much that of producing cores proper as that of producing mold parts. On Figs. 13 and 14 appear a certain number of cores realized according to the process and which are used for the making of various parts used in building an engine. One can see cylinder head cores, pipes and water jackets; inlet and exhaust manifold cores; cylinder block timing gear core and pulley grove cores. All these cores are exclusively produced in hot boxes, for production rates which can exceed 10,000 engines per week.

Their weight does not exceed 3 kg (6.6 lb) and they are solid. Their shape is that of conventional cores produced in oil sand. It is evident that for these types of cores which can be used without any finishing operation as soon as they leave the boxes, hot box coring constitutes the most rational means of production. It suppresses the dryers, the core wires and grinding of cores before assembly (in particular in the case of cylinder head cores).

A reduction in manufacturing time is the result thereof, as it is apparent in the chart:

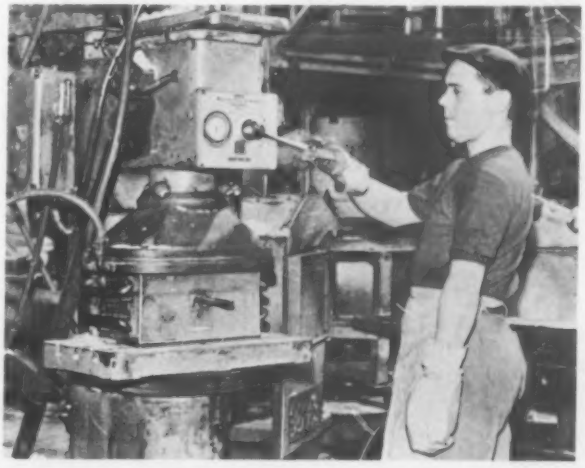


Fig. 9 — Four station unit. View of the blower station.

Fig. 10 — Four station unit stripping station.

Cores	Core production time in min: Conventional oil core	hot box core	Time ratios %
Cylinder head assembled cores: water jackets; plus pipes (aluminum)	16.5	4.5	27.3
Inlet manifold (aluminum)	1.90	0.45	23.7
Exhaust manifold (cast iron)	3.54	0.83	23.4
Timing gear core (cast iron)	3	0.91	30

It is thus possible to see that the production times are reduced by three quarters. The actual problem really is that of the limits of the process – how far can one go in weight and dimensions? For the time being, the company has not tried to produce cores with a thickness above 3 in. Under these conditions, the relative importance of the unbaked core body with regard to hardened outside layer is relatively small.

It is not thought that production of more voluminous cores is impossible, but beyond a certain volume it is necessary to take into account the quantity of sand used and the saving obtained by producing partly hollowed cores. Under these conditions the hollowing out of the core must be decided when the box is designed. An experimental realization towards

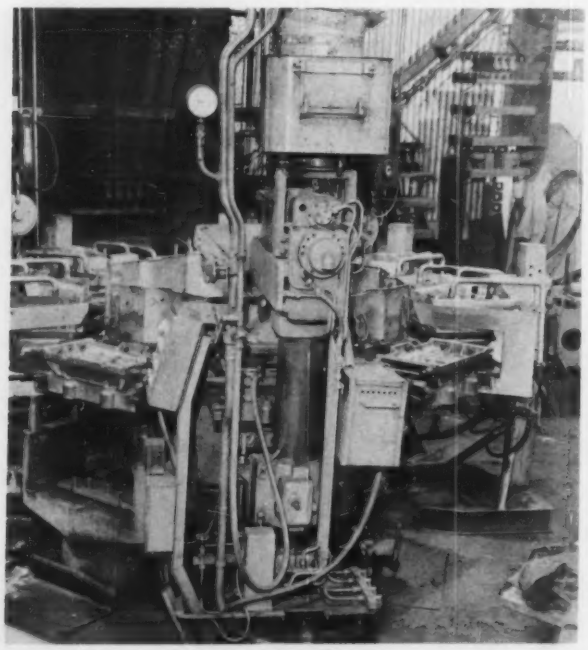


Fig. 11 — Eight station unit general view.

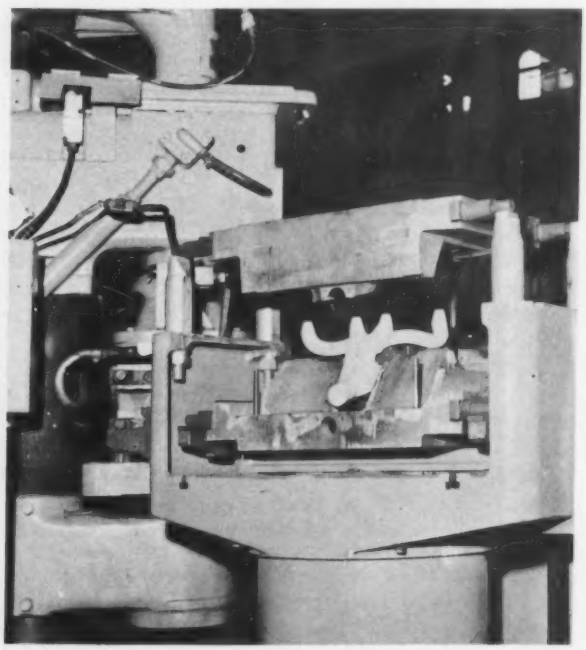
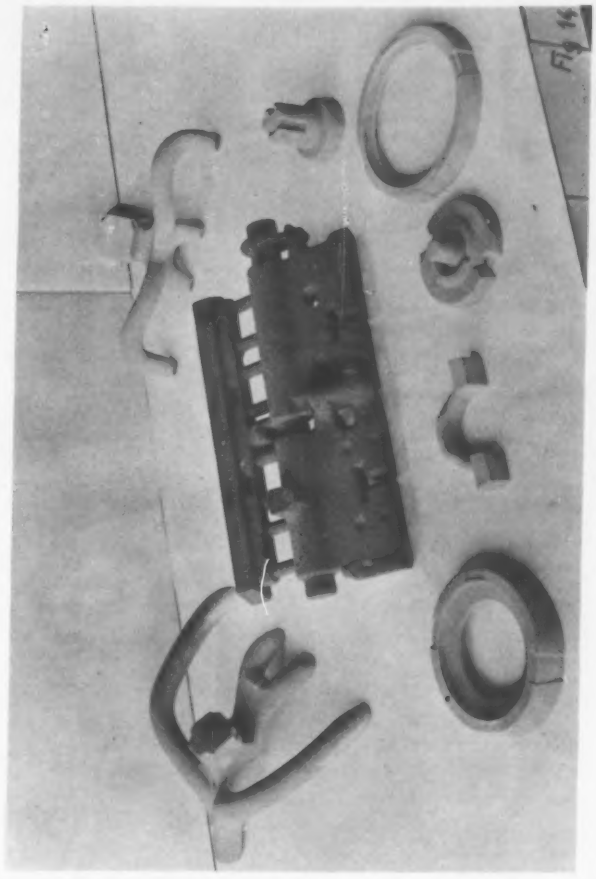
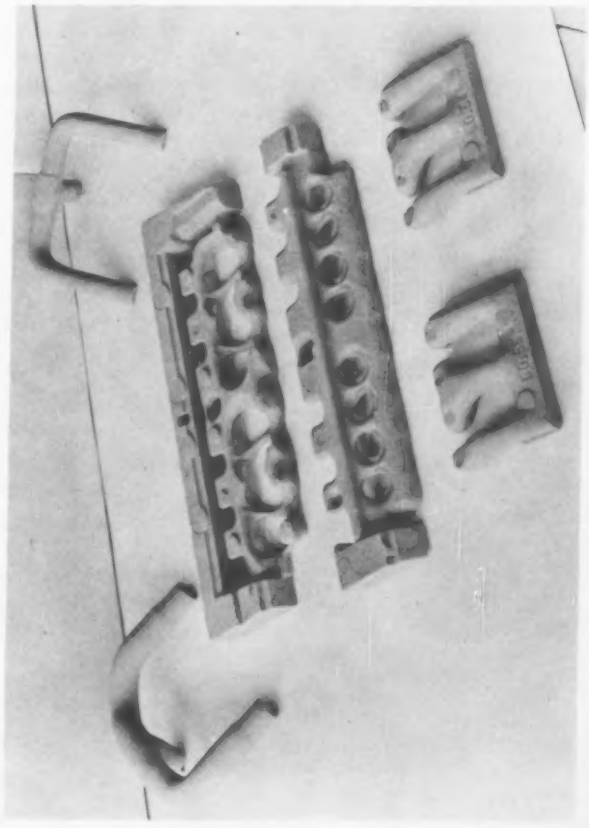


Fig. 12 — Eight station unit, view of the stripping station.

Figs. 13 and 14 — Samples of cores produced in hot boxes.





lightening the core has been carried out in the molding field. Figures 15a and 15b represent a half mold for a crankshaft, cavity side and opposite side.

It can be seen that large cavities have been made on the back of the core, the external shape of the core being maintained with narrow ribs. As it is, the core weighs 17 Kg (37.5 lb). It was obtained by blowing. Two cores of this type, assembled to form a complete mold are enclosed between two metallic plates fastened by clamps and cast without any intermediary packing to support the core part in contact with the metal. This method, in its experiemental stage for the time being, shows most interesting possibilities. It is a simple solution to the clamping problem for shell molds, and it is certain that numerous parts can be made this way.

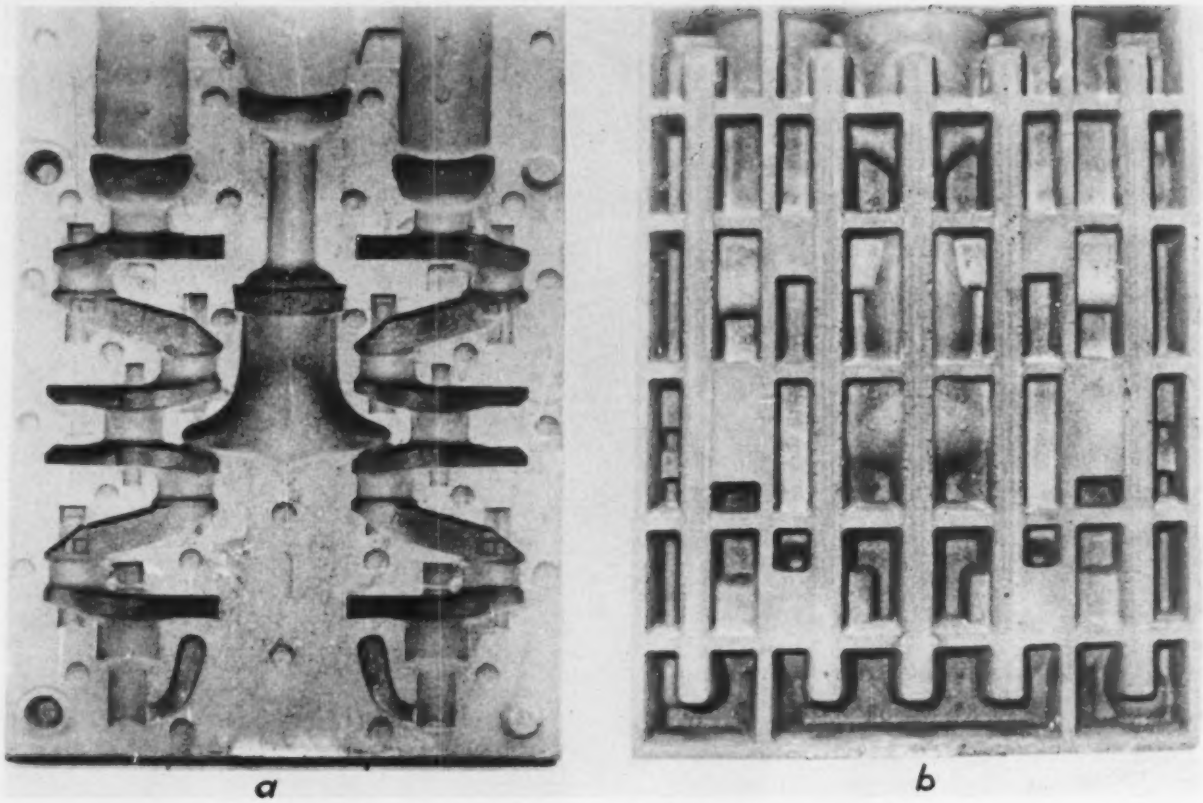
Other molding research has been carried out in the field of small parts in steel or special iron cast in stacks. In this case the company has taken advantage of the possibilities offered by the hot box process for making flat cores of regular geometrical shapes, therefore suitable for stacking and thus for stack molding. Figure 16 shows a certain number of molds of this type, as well as the corresponding castings.

These molds were obtained by the mixed technique which consists in filling the box by low pressure blowing and carrying on the ramming by squeeze and vibration. On Fig. 17 can be seen an application of this method of molding to the production of rocker arms. The two cores when assembled form one stage of the stack, the mold itself being made by the stacking of 12 cores topped by a sprue cup core. The whole stack is held together by clamps. On the right is a group of castings. The field in which hot box coring may be used seems to be relatively wide. It would seem, in particular, that the technique of the mold and core partly hollowed out and ribbed shows certain possibilities in the production of fairly large molds.

CONCLUSION

The hot box core production process seems to have succeeded in reconciling two tendencies which were in opposition until now, making more precise molded castings, at lower cost prices than those of the conventional methods. This result was obtained with the use of thermosetting binders and efficient and capable of polymerization when in contact with a hot box. It is thus possible to obtain a core or part of a mold which reproduces faithfully the boxes used to form them. Standard mixers and blowers are used in this process, which suppresses many of the numerous operations which are so expensive in the traditional methods.

In favor of this coring method are (1) simplification of sand preparation and suppression of dryers and drying plates, core wires, large core ovens, generally bottle necks in core production shops. These



Figs. 15a and 15b — Samples of hollowed and ribbed molds produced in hot boxes.

ovens are replaced by small heater units with a high thermal efficiency, therefore saving fuel and accuracy of core assemblies which normally reduces finishing operations. It is to be noted that these results can only be obtained with high quality core boxes, which must be studied with extreme care.

Examples have established the present possibilities of the process, whether it be for the production of cores for different parts, or for molds for small or medium parts. It is believed the hot method will allow sand molding to maintain its position as a mass production process.

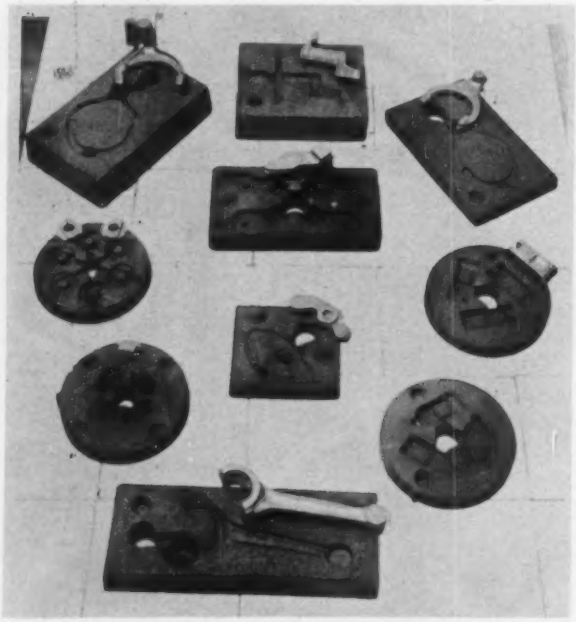


Fig. 16 — Molds for stack molding.

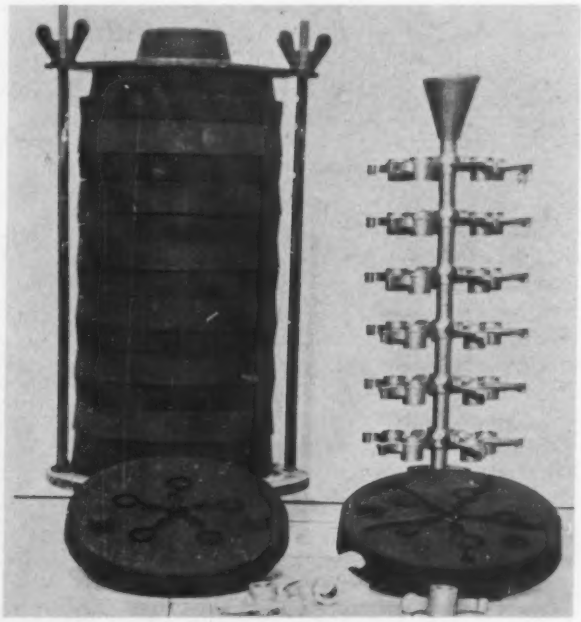


Fig. 17 — Stack castings of rocker arms.

DUCTILE IRON GRAPHITE FORM CLASSIFICATION

by C. K. Donoho

ABSTRACT

Graphite type and size charts are presented for the rating of structures of ductile irons. Charts are needed to classify graphite forms of spherulitic shape, and modifications between flake and spherulitic graphite. Matrix structure is estimated by examination of etched specimens under magnification and estimating percentages of carbides, pearlite and ferrite. These charts are offered as an interim suggestion until standards have been established for these graphite shapes and sizes.

INTRODUCTION

A.S.T.M. Standard A-247-47 was developed prior to 1941 by a Joint Committee of AFS and A.S.T.M. This standard has served its purpose well, and references to Type *A* and Type *D* graphite, the most frequently used, have become bywords in descriptions of gray iron structures. A-247, of course, pertains only to the types, and more specifically, to the distributions of flake graphite in gray cast iron. Obviously, there is now a need for further classifications to include spherulitic graphite and modifications or transition forms between flake and spherulitic graphite.

GRAPHITE CHARTS

The first published work that we have seen which includes classification by type and size of spherulitic graphite (Kugel Graphit) is that proposed by the Cast Iron Committee of the German Foundrymen's Association under the chairmanship of Dr. A. Wittmoser. In its complete form, this classification uses A.S.T.M. A-247 for the flake graphite types and sizes, and adds charts for spherulitic graphite and for temper carbon graphite as seen in malleable iron.

The charts for type and size of spherulitic graphite (including transition forms) are reproduced as Figs. 1 and 2.

These can be used satisfactorily to grade or specify ductile irons as to microstructural quality. Type *K* is, of course, the most desirable for optimum mechanical properties, and usually the smaller graphite sizes are preferred. A typical specification might be — at least 75 per cent Type *K* with not more than 15 per cent of Type *P* and size 3 or finer. This rating has been used effectively at the author's company in routine quality control.

C. K. DONOHO is Chief Met., American Cast Iron Pipe Co., Birmingham, Ala.

Along with the graphite types and sizes, the average percentages of pearlite, ferrite and carbides, if present, are also recorded. This can be used conveniently to describe ductile iron metallography for practically all grades of ductile or semi-ductile irons.

INTERNATIONAL COMMITTEE STUDIES

There is also an International Committee on Methods of Testing Cast Iron, Prof. A. deSy, *Chairman*, which is studying graphite classifications, and hopes to have a final draft approved soon. Other graphite classification schemes include the Italian specification UNI-3775, and Czechoslovakian specification CSN-42-0461. The International Committee is considering all these as well as the German system in an effort to produce a truly International Specification on graphite classification.

Through Dr. A. B. Everest of the Mond Nickel Co. and AFS headquarters, preliminary charts from this work have been seen, but since these have not had final approval of the I.S.O., they cannot be reproduced.

In the studies of graphite forms encountered in ductile iron, the chart, shown as Fig. 3, was evolved. This is similar to the German classification chart in that five types are shown. However, our Type V is not included in the German classification. That Type V does occur is shown by the micrograph, Fig. 4. There is some question that Type V occurs frequently enough to warrant inclusion in the standard chart.

Type I is the most desirable type for most purposes, but the presence of Type II does not affect properties adversely to any marked degree. Type III is the quasi-flake or vermicular graphite which is usually associated with an insufficient magnesium content. Some Type IV graphite is seen when magnesium content is excessively high, or in the presence of certain subversive elements. At present, the mechanism or the cause of the formation of Type V is uncertain.

Roman numerals were selected for the type designations because this avoids any confusion with A-297 letter designations for flake graphite distribution.

GRAPHITE SIZE CLASSIFICATION

Figure 5 is an attempt to effect a size classification based on inches and maximum diameter of the graphite particles. However, this proved to be rather awkward, and the German size chart based on area and millimeters is currently preferred.

Figure 6 is a micro of an iron with predominantly

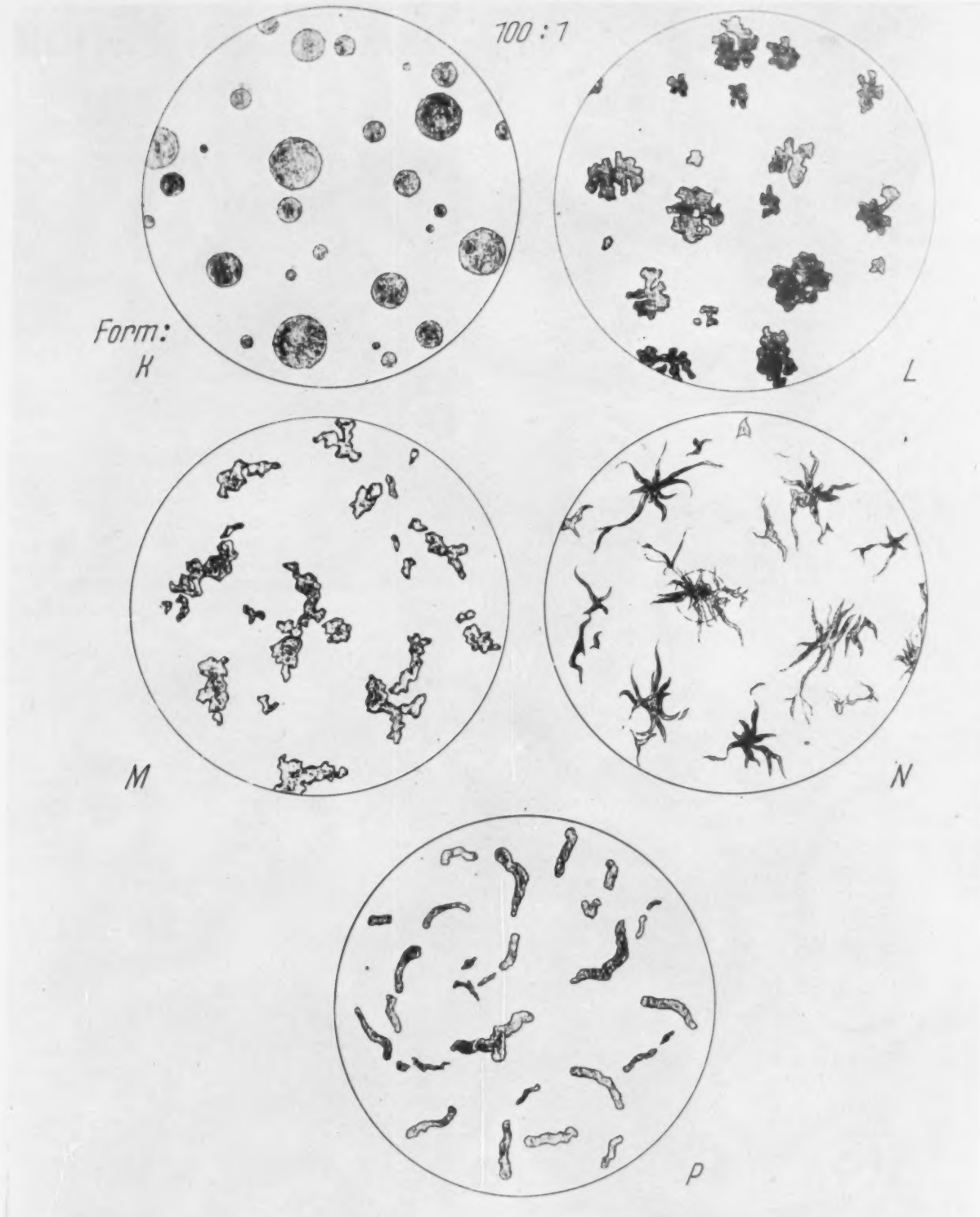


Fig. 1 — Types of graphite proposed by the Cast Iron Committee of the German Foundrymen's Society.

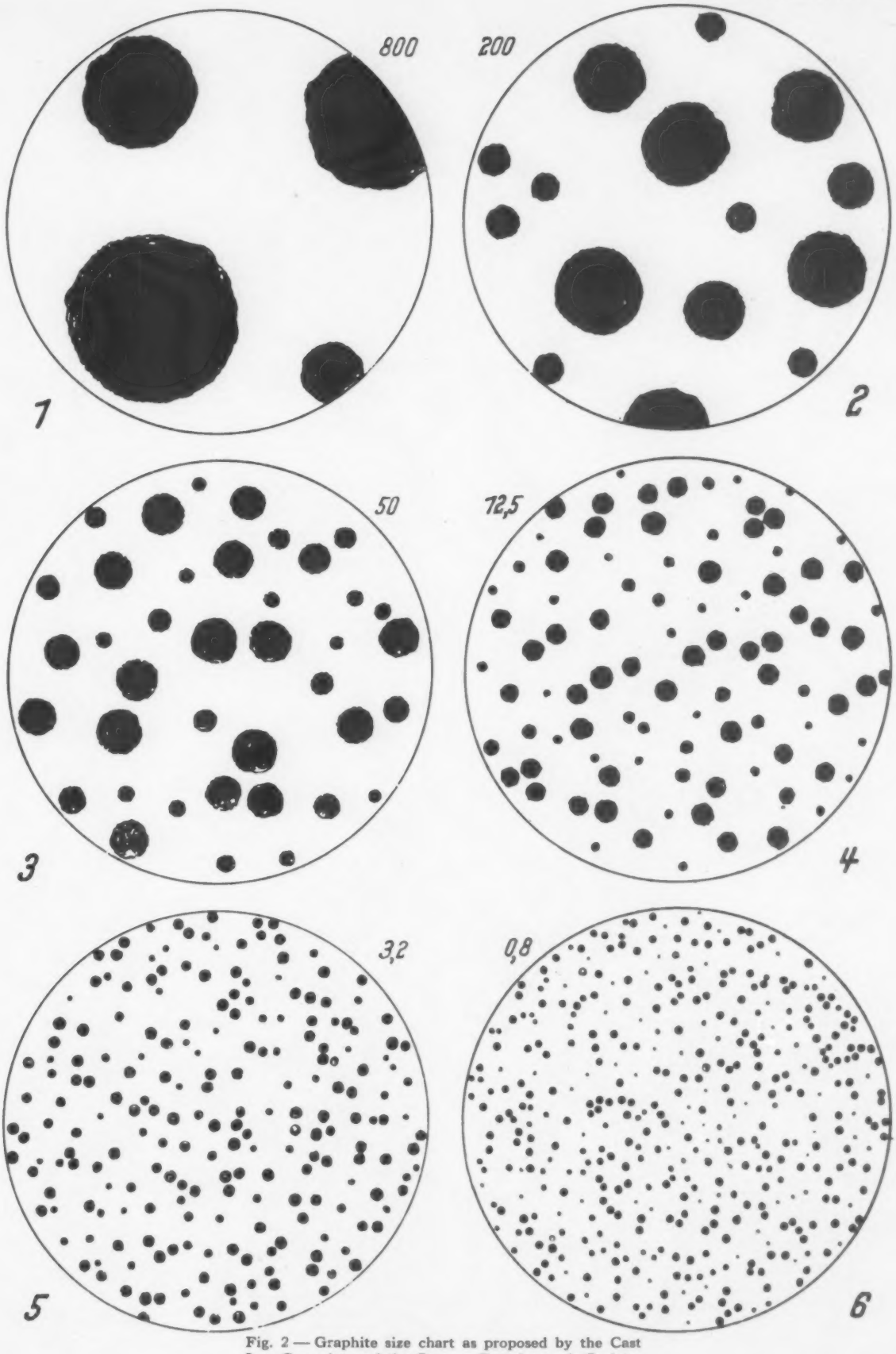


Fig. 2 — Graphite size chart as proposed by the Cast Iron Committee of the German Foundrymen's Society. 100 ×.

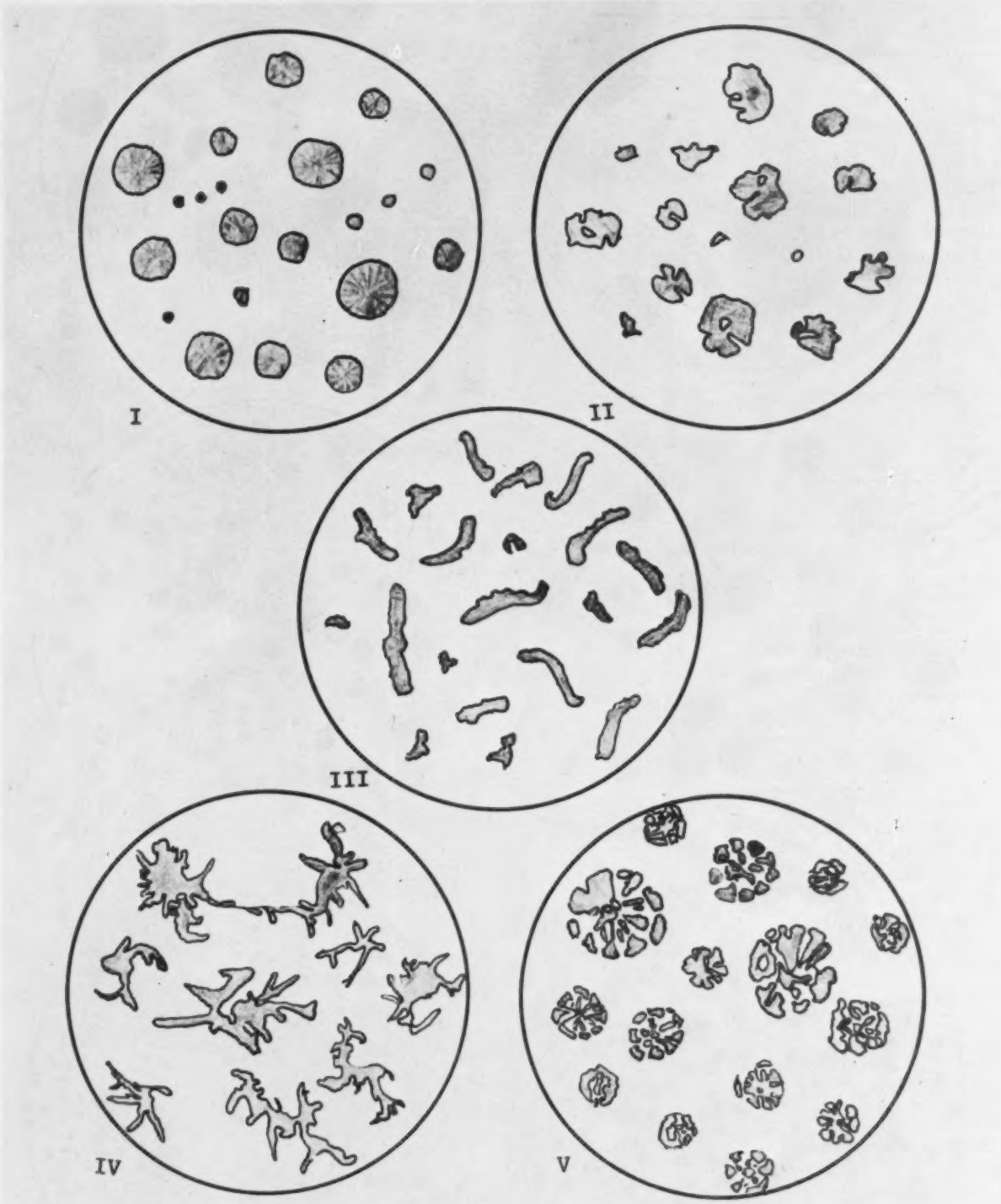


Fig. 3 — Classification of graphite forms in ductile cast iron as proposed by the author. 100 ×.

Type I (or Type *K*) graphite. At 100 ×, the size rating by Fig. 2, was 4. With less than 10 per cent pearlite as-cast, the tensile properties in the as-cast condition were somewhat higher in ductility than usually found. Figure 7 is a micro of a ductile iron just slightly deficient in magnesium content. Figure 8 is a micro of a ductile iron with excessive magnesium content showing occurrence of Type IV graphite as-cast. These last three micros were taken at 200 × in order to show clearly the graphite type. For size rating, the samples were, of course, viewed at 100 ×. For matrix rating, the samples were etched in nital.

In Table 1 are shown the metallographic ratings of these three samples, and the corresponding as-cast tensile properties as obtained from one in. keel block coupons. Graphite type ratings are by Fig. 3 and size ratings by Fig. 2.

TABLE 1

Structure, Unetched	Graphite		Matrix, %			As-Cast Tensile Properties		
	Type	Size	Carbides	Pearlite	Ferrite	T. S. ×10-3	Y. S. ×10-3	Elong., %
Fig. 6	I	4	0	10	90	81.6	62.6	19.1
Fig. 7	I, 60% III, 40%	4	0	30	70	81.2	60.5	9.6
Fig. 8	I, 90% IV, 10%	4	0	20	80	83.7	65.4	5.9

It is to be noted, from samples in Figs. 7 and 8, that considerable quantities of graphite types other than Type I can be tolerated and still meet 80-60-03 requirements. The sample of Fig. 6 meets the tensile requirements of 60-45-15 as well as 80-60-03.

REGRESSION EQUATIONS

Grant Thomas* of Deere and Co. has shown statistically that up to 10 per cent of vermicular or Type III graphite may be tolerated with only minor reductions in physical properties. He has calculated from statistical data the effect of vermicular (Type III) graphite on tensile strength, yield strength and elongation of as-cast ductile iron. These regression equations are as follows:

Change of T. S., psi
= −1380-189 (% vermicular graphite)
Change of Y. S., psi
= −1250-65 (% vermicular graphite)
Change of Elong., %
= −0.70-0.12 (% vermicular graphite)

Assume that normal as-cast ductile iron of all spherulites, or Type I, graphite has the following average properties:

T. S., psi 90,000
Y. S., psi 65,000
Elong., % 12

These are not unusual properties, and represent what is normally obtained on as-cast tensile tests machined from keel block coupons when the graphite is predominantly spherulitic.

*G. F. Thomas, "How Do You Know It Is Ductile?" AFS TRANSACTIONS, *vol. 68*, p. 182 (1960).

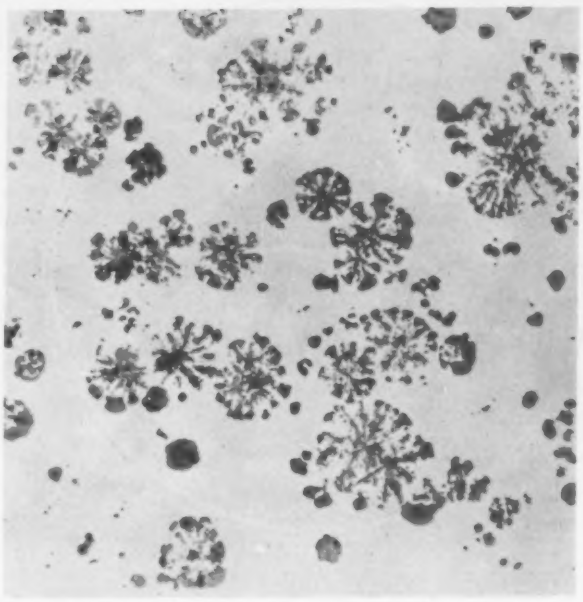


Fig. 4 — Type V graphite. Unetched. 100 ×.

Using the Thomas regression equations, the properties to be expected with varying percentages of vermicular, or Type III, graphite can be calculated.

TABLE 2 — VERMICULAR GRAPHITE EFFECT ON TENSILE PROPERTIES OF AS-CAST DUCTILE IRON

Vermicular Graphite, % ..	10	20	30	40
T. S., psi	86,730	84,840	82,950	81,060
Y. S., psi	63,100	62,450	61,800	61,150
Elong., %	10.1	8.9	7.7	6.5

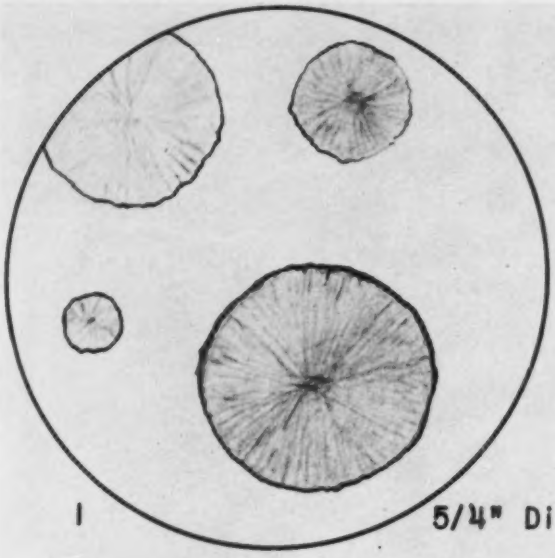
From Table 2, with the assumptions made, it is seen that the calculations show that 80-60-03 requirements can be met with up to 40 per cent vermicular, or Type III, graphite. This is confirmed by an actual test, Table 1, Fig. 7. Indications are that a small amount of the "spiky" or Type IV graphite is more detrimental to ductility than is the vermicular type.

Of course, the effects of compositional variables on ductile iron properties are of considerable importance. These effects have been purposely minimized in this discussion which deals primarily with structural effects on irons of generally normal compositions.

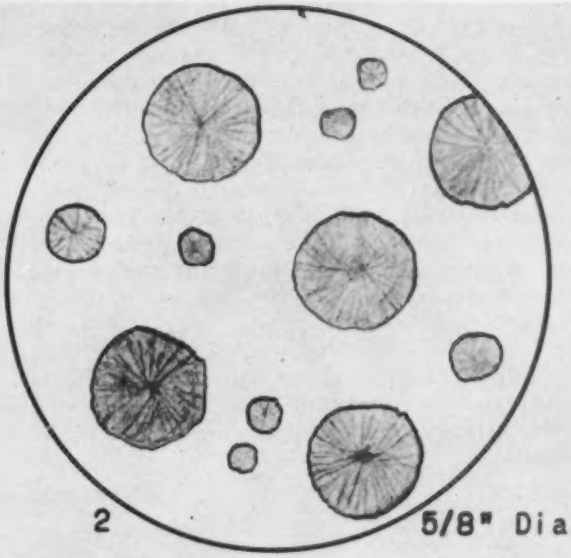
SUMMARY AND RECOMMENDATIONS

Graphite type and size charts are presented which may be used to rate the structures of ductile irons. Present preference is to rate the graphite type by the chart, shown as Fig. 3, and the graphite size by the German square millimeter chart, shown as Fig. 2. The graphite type may be estimated at any convenient magnification, but 100 × is the standard magnification for size rating.

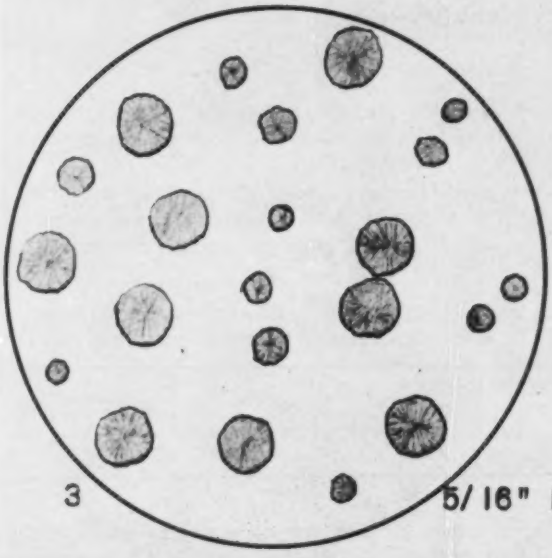
Matrix structure is estimated by examining etched



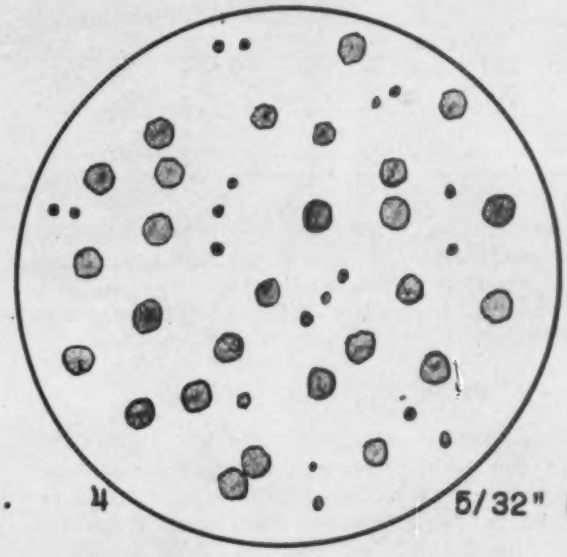
1 5/4" Dia.



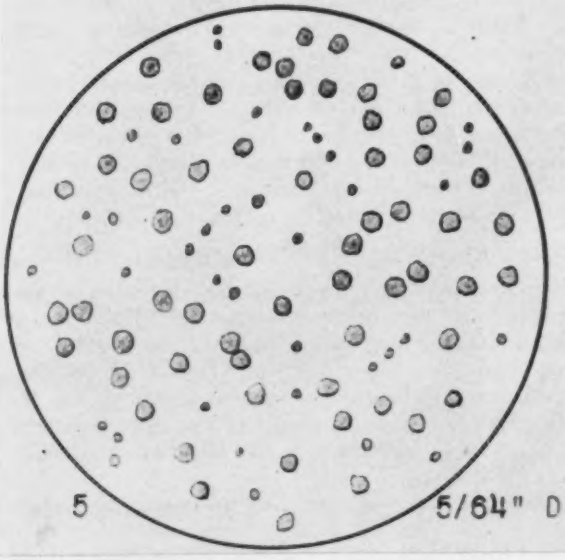
2 5/8" Dia.



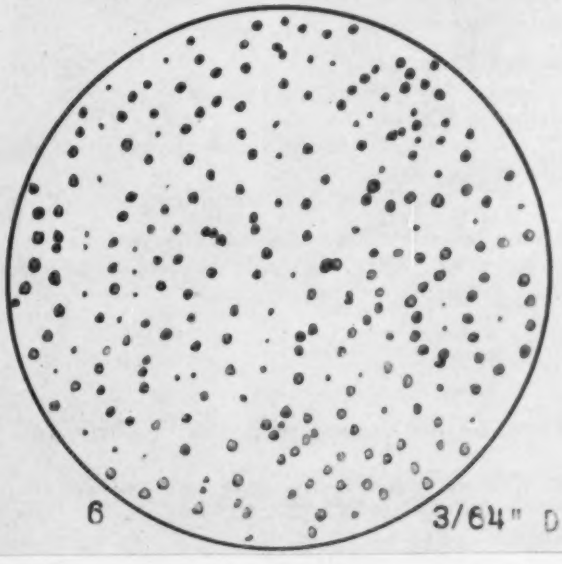
3 5/16" Dia.



4 5/32" Dia.



5 5/64" Dia.



6 3/64" Dia.

Fig. 5 — Classification of graphite size in ductile iron based on inches and maximum diameter. 100 ×.

specimens at suitable magnification, and estimating the percentages of carbides, pearlite and ferrite. It is shown that sizable percentages of graphite types other than Type I (Fig. 3) can be tolerated without serious effect on tensile properties.

It is proposed that this discussion be considered as an interim suggestion until the International Committee's standard for the classification of graphite has been approved by I.S.O. At that time, the American organizations concerned can decide whether to accept the International Standard or proceed to develop a separate American Standard.

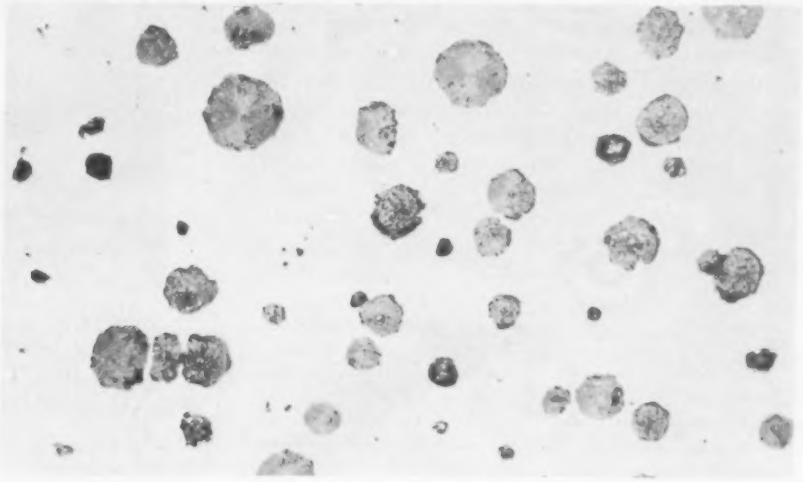


Fig. 6 — Ductile iron with Type I (or K) graphite. Unetched. 200 ×.

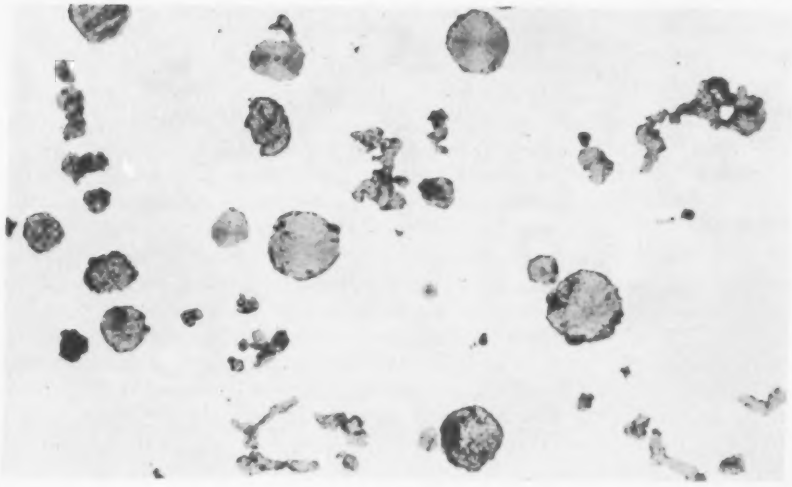


Fig. 7 — Ductile iron with 60 per cent Type I, 40 per cent Type III graphite. Unetched. 200 ×.

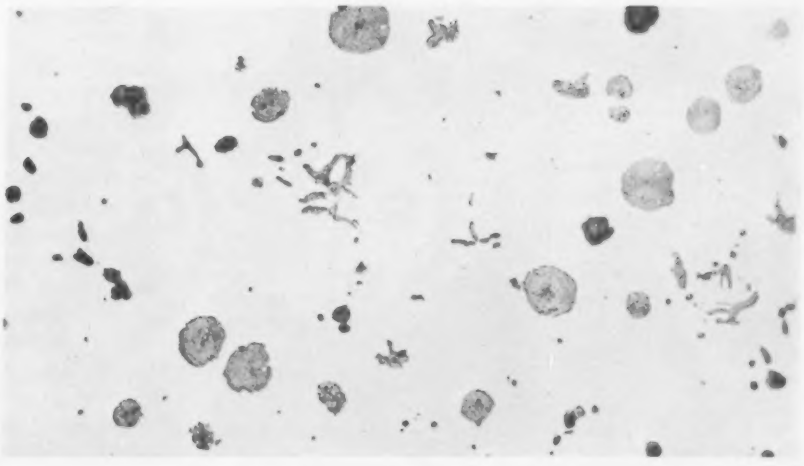


Fig. 8 — Ductile iron with 90 per cent Type I, 10 per cent Type IV graphite. Unetched. 200 ×.

PLASTIC PATTERNMAKING

The polyurethane concept

by Henry A. Burton

ABSTRACT

Throughout the years, patternmaking has remained static in respect to use of wear resistant materials for the foundry industry. In all probability, hard chromium plating is the ultimate in abrasion resistance of patterns and core boxes for high production runs. However, objectionable features of this particular process have been the extremely high cost factor and size limitation, coupled with expensive pattern equipment necessary for the application of hard chromium surfacing. This article outlines and describes methods whereby highly resilient plastics and metals help provide ideal abrasion resistant characteristics and low cost hitherto deemed impossible in processing of foundry pattern equipment.

INTRODUCTION

Introduction of the epoxides to the foundry industry has greatly stimulated the imagination in pattern construction particularly where abrasion resistance is concerned, and is principally influenced by the versatility of the materials in liquid form. Complexity of shape or size is still further enhanced by the elimination of machining to the end product. This signifies to some extent that abrasion resistive materials may be introduced to the pattern or core box at indicated or anticipated wear sections with little or no effort on the part of the builder.

Experiences in the past with erosion and destructive action of sand slingers, or erosion caused by the blow-down action in core blowing, point out the folly of subjecting wood patterns or core boxes to such treatment on the basis of medium or heavy production. However, there are at hand today a number of abrasive resistant materials to overcome erosion to some degree.

These abrasion resistant materials take the form of isocyanates, wear resistant epoxy resins, hard chromed plate, etc. These materials over a period of time have proved their worth in combating erosion, not only through the medium of sand slinging or core blowing, but also in other phases of operation throughout the foundry. Erosion to high production metal patterns subject to sand slinging has led to experimenting with materials foreign to normal patternmaking procedure.

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Ethers and Esters

Metallic filled plasticized epoxy resins seem to have been positioned between wood and aluminum in respect to wear resistance of pattern equipment. Synthetic materials are not cure-alls in foundry erosion problems, Yet, in some aspects of patternmaking, they excel over aluminum or other materials in the rigid state. Prolonged evaluation over the course of the past six years has made it abundantly clear that the epoxides surpass aluminum in core box construction material for core blowing. Core boxes with a surface area up to 300 sq in. have produced cores in excess of 30,000, even without erosion in core box cavities opposite to blow down holes of core blowers.

It is indeed reasonable to assume the answer to erosion free plastic pattern equipment lies in the general direction of superior grade plasticizers, providing resilience necessary to overcome impact shock. From all outward appearances, epoxides more or less resemble a rigid material. Nevertheless, barcol impressor testing indicates a hardness within the range of 40-45 barcol. Whereas aluminum, on the other hand, depicts readings in the neighborhood of 70.

This barcol differential should establish epoxy resins as a highly resilient material. It then naturally becomes apparent why synthetics stand up so well under core blowing conditions, with subsequent reduction of wear through resilience.

Polyester Resins

Little thought had been given in the past to polyester resins, primarily due to their extremely high shrinkage. However, here is a synthetic material which can be of exceptional value and assistance to the patternmaker. Filled polyesters have long found a ready market in the automotive body repair field, principally for their splendid adhesion qualities, coupled with fast curing properties (up to a 10 min cure time).

What makes polyesters so interesting and attractive to the patternmaker stems from the fact that adhesion properties are such as to withstand chipping under sand slinging conditions. Surface preparation includes metal rough up and solvent cleaning as the

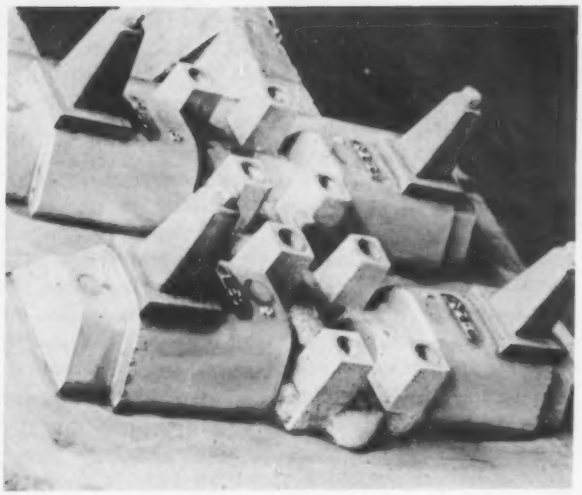

Fig. 1 — Blind heads mounted for high production.

only requirements necessary in obtaining a good bond. Extremely fast curing properties with dimensional stability after cure further enhance filled polyesters in patching and repairing of wood or metal pattern equipment.

All in all, the fact remains there are definite applications for the material, even if material imbalance manifests a high incidence of shrinkage, coupled with the fact they do not adhere to the epoxides.

INDUSTRIAL RUBBERS

Prior to the entrance of plastics to the foundry scene, some work had been accomplished utilizing industrial rubber as a resilient material in combating wear to pattern equipment. However, it was easily seen the material had limited scope, inasmuch as rubber, in order to fashion a pattern into any desired shape or form, required the employment of expensive die forming equipment. Rubber, therefore, became economically impractical for prototype pattern work.

An outstandingly successful application was found in the shape of blind heads for jolt machine work. The elasticity of the material enabled the use of ram-up cores, virtually eliminating core breakage. Figure 1 shows blind heads mounted for high production. Considering that the pattern equipment has completed over eight years of satisfactory service without wear or further adjustment should demonstrate the fact that elastomeric materials have a value in the foundry.

Another application for elastomeric materials in the shape of rubber open heads is seen in Fig. 2 set up for jolt machine work. In some cases, industrial rubber has been used to advantage in overcoming the wear experienced to heads under slinger operations. There are, of course, limitations in part, such as caused by the flexibility of the material in solid form.

For the want of another term, limitations of materials could aptly be described as "material imbalance." This so called imbalance is frequently encountered in patternmaking materials. A case in point is that of the subject matter under discussion, lowered durometer hardness results in higher abrasion resistance, increasing elasticity and, by the same token, effects greater distortion under impact. On the other hand, increased durometer hardness sharply decreases the abrasion resistance of the material.

Wishful thinking has led to the thought that if any synthetic resilient material could be developed along the lines of ideal abrasive resistant characteristics, such as exemplified by low durometer rubber, it would prove of immense interest and satisfaction to the patternmaker in combating erosion problems.

The arrival of a two component cross linking polyisocayanate castor oil based material, apparently possessing to all appearances the same characteristics as a flexible rubber, suggests this material may be a possible answer to major erosion problems in the foundry.

SYNTHETIC ELASTOMERS

Isocyanates or diisocyanates, more commonly referred to as polyurethanes or urethanes are gradually making an appearance and slowly gaining acceptance in the foundry.

The history of urethanes is quite interesting. They first appeared well over a hundred years ago. It is only in late years that they have gained any importance commercially. One hears of ethyl urethane in medicine as a producer of sleep. Other applications of solid elastomers are in the form of synthetic rubber tires, bushings, ring seals and the like.

On the other hand, flexible and rigid urethane foams are being applied extensively in aircraft and automobiles as paddings, fillers and so forth. In fact, there are a thousand and one commercial products on the market where they are used to advantage. Tri-

Fig. 2 — Elastomeric materials in the shape of rubber open heads set up for jolt machine work.

Fig. 3 — Core box showing hard chromium plated facings in cavity and loose pieces to reduce loose piece stick.

isocyanates are used in coatings such as paints and lacquers to provide wear resistance and act as a dirt repellant. It would not be at all surprising if they eventually show up as satisfactory coatings for wood patterns.

The physical properties of urethanes are such they lend themselves quite easily for their ability to withstand heavy impact shock, which makes them particularly interesting and adaptable in the field of abrasion resistance for the foundry.

Investigation and evaluation of the remarkable elastomeric or rubbery like material shows a great deal of promise under test. When applied in gelcote form, modulus of elasticity is so low when backed up by rigid materials, it is of no practical importance nor gives any cause for concern whatsoever. This implies no visual dimensional change under load to the ultimate end product.

Abrasion Resistance

Repeated experimentation with elastomeric polyurethanes as a pattern medium has in all cases manifested superior abrasion resistance over a number of rigid materials in use today. However, this superior resistance to abrasion does not mean the materials are adaptable to all phases of operation in patternmaking. Unfortunately, material imbalance restricts the use of urethanes as a possible solution to extreme wear in quite a number of unusual ways.

Urethanes are hygroscopic in every sense of the word, this condition definitely retards speed in reproduction to a marked degree. It indicates all moisture must be completely eliminated from the form or mold, otherwise the end product will develop surface pin holes. Hygroscopy also shortens storage life. Applied in gelcote form, urethanes require a mechanical other than chemical bond. Method of providing a satisfactory mechanical bond is relatively simple. After the urethane gelcote is applied to the form, flock in the shape of ¼-in. steel or aluminum fibers are scattered over the coating before application of epoxides when laminating for strength. There has been no evidence of bond breakdown by following this particular method, even after the production of 5000 cores. This suggests the method has merit, especially when cores are produced by air ramming.

There is also the question of cure time and sand stick. Urethanes require a 24 hr cure plus additional heat curing to completely eliminate sand stick. All these elements point out there is considerable delay in processing a urethane coated pattern or core box, delay which, in most cases, the foundry cannot afford.

These several points have been brought forward to emphasize the importance in weighing the pros and cons of urethanes as a pattern medium. Prior to the inception of epoxy resins in foundry work, great hopes had been held for phenolformaldehyde, then found wanting, simply because of the fact they would not bond to materials other than themselves. This soured and slowed down the use of resins by a number of companies for a considerable time. This lesson also applies to urethanes, they too should be evaluated only for their own particular requirements.

There is, however, a brighter side in the use of urethanes for the foundry. They show up remarkably well under speed slinging conditions. An interesting study and possible solution to extreme wear is seen on a urethane gelcoted pattern under tests. Seven thousand five hundred molds have been produced up to the moment without any indication of wear, yet on the other hand, epoxy resins have failed to produce more than 300 molds under the same harsh conditions.

In brief, the patternmaker has now under his command a highly elastomeric material in which to combat erosion on foundry pattern equipment, erosion which gives a great deal of concern to all parties involved in expediting the equipment to the foundry.

CONCLUSION

From observation, evidence points out two factors in erosion resistance. There is on the one side, rigid or hard surfaced materials which are highly resistive to wear, whereas on the other side, there are the resilient materials, which in all probability could surpass any other material in the rigid state to retard or eliminate erosion. It is quite evident that the inception of synthetics to the foundry industry has presented the patternmaker with a much larger and wider scope in attempting to combat erosion through the use of resilient materials, and has been directly instrumental in providing ways and means whereby patternmaking follows or keeps abreast of foundry technology.

CALCIUM CARBIDE USE IN ACID CUPOLAS

by R. Schulze

ABSTRACT

A special calcium carbide having a melting point sufficiently low to melt and burn in the combustion zone of the conventional acid cupola is described. This material has found wide use in West German iron foundries as a cupola addition to raise the temperature of the iron, increase melting rates and permit a reduction in the amount of coke used in the melting process. Lowered coke consumption results in a reduction in the sulfur content of the iron. Typical examples of the use of the special carbide and the results obtained are given.

INTRODUCTION

This report is a summary of experience in West Germany since 1954 involving the use of a special calcium carbide of low melting point as a cupola charge addition.

Calcium carbide is a dark gray stone-like substance obtained by fusing coke and lime in an electric furnace. In general appearance and weight it resembles a crushed gray limestone and when added to the cupola charge it is used in similar sizes. The principal use of calcium carbide is for the generation of acetylene, a fuel gas used in welding and cutting of metals, and in the chemical industry as a basic material for the production of many chemicals. The carbide which is used for acetylene production contains approximately 80 per cent calcium carbide (CaC_2), the remaining 20 per cent consisting mostly of lime (CaO) plus small amounts of minor impurities.

Calcium carbide of this grade has a melting temperature of approximately 3400 F (1870 C), and cannot melt at temperatures existing in the melting zone of the cold blast acid cupola. The special carbide is of a eutectic composition. It contains approximately 72 per cent calcium carbide, with the balance mostly lime and melts at about 2970 F (1632 C).

The first systematic experiments involving the addition of carbide to cupola furnaces were performed by S. F. Carter.[1] The results of his experiments with the use of commercial calcium carbide (welding carbide) in basic hot blast cupolas were reported at the AFS Annual Meeting in 1950. Carter found that addition of carbide to the basic cupola increased metal temperature and produced iron of lower sulfur content. The excellent results from the addition of carbide to basic cupolas reported by Carter caused several West German foundries to attempt to obtain higher temperature iron and lower sulfur in cold blast cupolas operated with acid slags.

EXPERIENCE WITH CARBIDE IN THE CUPOLA

H. Timmerbeil[2] has reported several experiments performed at the Vollmarstein Steelworks of Knorr Bremse since 1952. The addition of 2 per cent commercial calcium carbide (welding carbide of 80 per cent CaC_2) without change in the coke charge yielded a decided temperature increase. This permitted a reduction in the coke charge of about one-third when melting iron for the side blow converter process and for the production of malleable iron. The iron at the spout was of equal temperature to that obtained by the usual practice involving the use of more coke (without carbide). When the coke charge was lowered, melting capacity increased and the sulfur content of the iron was reduced.

From the fact that the carbide became effective slowly and that unconsumed carbide remained in the cupola drop, Timmerbeil concluded that the normal carbide is not sufficiently reactive (Carter also observed this). To overcome these difficulties the author's company developed a special carbide of lower melting point. This special carbide contains about 72 per cent CaC_2 and corresponds to a eutectic in the system CaC_2—CaO, illustrated in Fig. 1. The eutectic carbide begins to melt at 2966 F (1630 C), a temperature about 360 F (180 C) lower than for normal calcium carbide.

This special carbide has been used successfully in acid cold blast cupolas at the Volmarstein plant since 1954. In Sept. 1956, it was announced at the International Foundry Convention in Dusseldorf.

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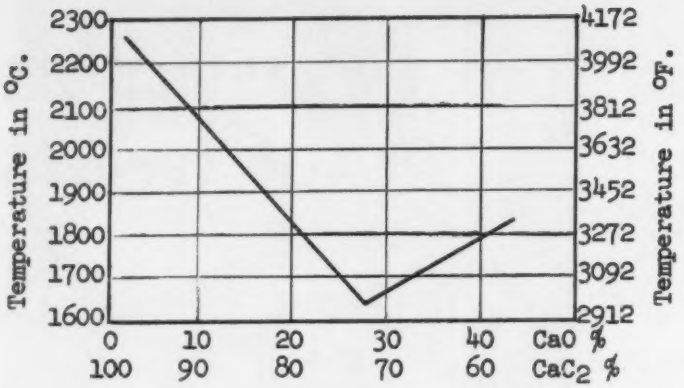

Fig. 1 — Melting temperature in the system CaC_2 — CaO (Ruff and Foerster).

Since then calcium carbide has found use in iron foundries of all types. R. Schulze[4] has reported concerning the practical application of calcium carbide and the nature of its reaction in the cupola. W. Patterson, F. Neumann and H. Trump has systematically investigated the influence of calcium carbide in the melting process in an experimental cupola at the Aachen Institute of Technology.

The results have been presented in diagrams showing the relation between coke charge, carbide charge, blast volume, melting capacity and iron temperature. The results reported by F. Neumann[5] confirmed experience gained in actual furnace practice. Figures 2 and 3 illustrate results obtained from the use of calcium carbide in melting gray iron.

It will be noted the consumption of coke for steel-free charges is reduced from 13.5 to 10 per cent when 2 per cent carbide is used. This is sufficient coke to maintain the correct height of the coke bed and the addition of coke booster charges is not necessary. The temperature of the iron at the spout increased 70 to 90 F (21 to 32 C) compared to the practice involving heavier coke consumption but without calcium carbide. The increased melting rate from 4.3 to 5.3 tons/hr should also be noted.

The reactiveness of calcium carbide is evident when a cupola heat is started. When 2 per cent carbide is used the first tap is hotter; 4 per cent carbide on the bed coke and on the first charge results in a rapid temperature rise. The first iron is 140 to 180 F (60 to 82 C) hotter and can be easily cast.

The rapid rise in metal temperature from use of calcium carbide is used to insure a hot start by some foundries who do not employ carbide during the

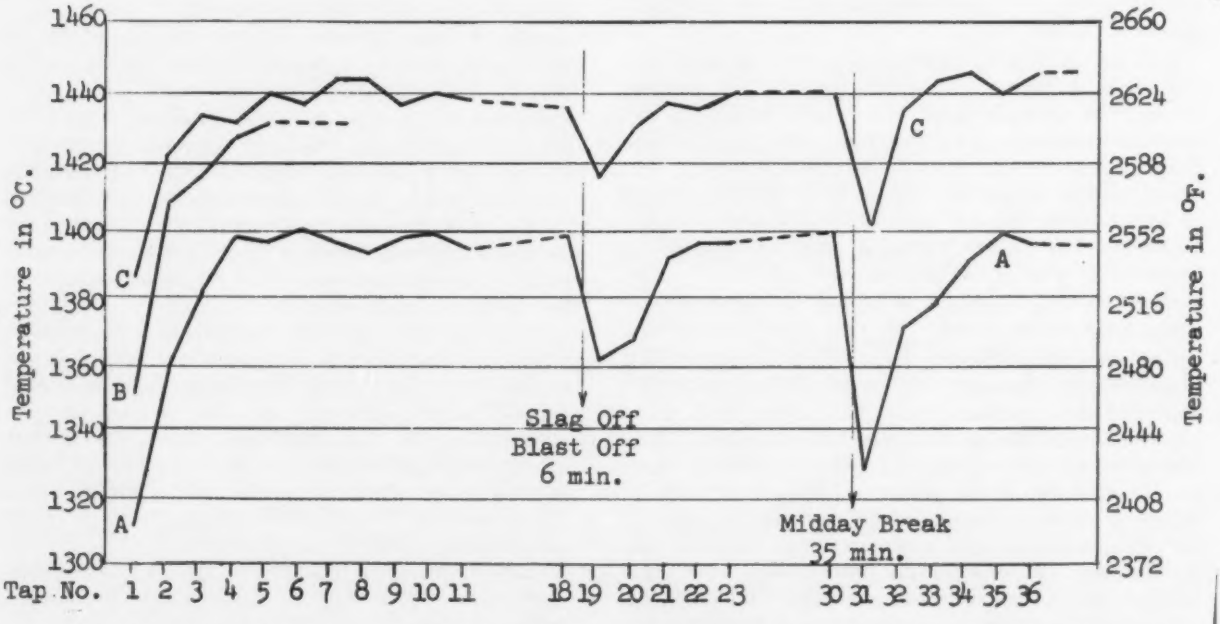

Fig. 2 — A comparison of heats melted with and without carbide using an acid cold blast cupola of 32 in. diameter in continuous production of soft iron. Charge weight 880 lb. A) With 13.5% charge coke, 4% limestone (Taps one and 31 were pigged). B) With 10% coke, 1% stone, 2% calcium carbide. C) With 10% coke, 1% stone, 4% calcium carbide on the bed coke and first iron charge, 2% calcium carbide on the following charges. Melting Capacity: A = 4.3 tons/hr — C = 5.3 tons/hr. Temperature measurements were obtained by optical pyrometer adjusted with an immersion thermocouple. Two readings were taken at the spout per tap.

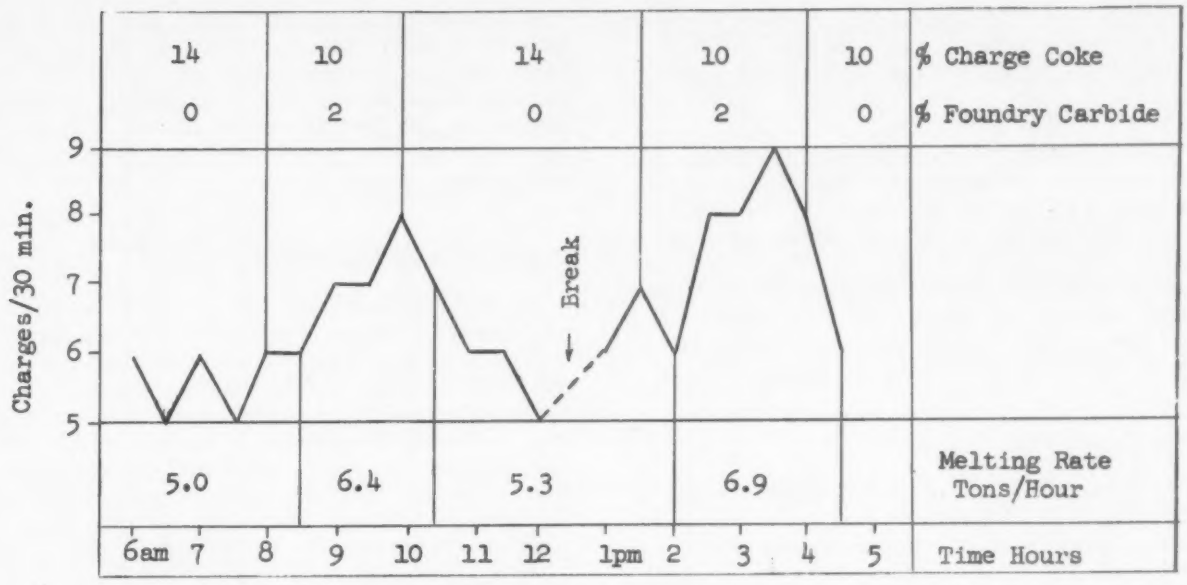

Fig. 3 — Adaptation of melting capacity to the need for iron — cold blast cupola, 35 in. diameter, charge weight 880 lb (A uniform charge with regulation of the silicon content by ladle addition according to the specification of the casting).

balance of the heat. It is also used to compensate for planned shutdowns such as the lunch period. The last charges before the shutdown receive a carbide addition timed so that the carbide just reaches the coke bed when the blast is taken off. Careful handling results in a negligible temperature drop.

It has been shown that an increased melting rate results when carbide is used to permit a reduction in the coke charge. Thus, use of calcium carbide makes it possible to alter the melting capacity of a furnace to meet changing needs of the plant, for instance in plants needing extra iron temporarily for the pouring of small castings during a regular run of heavier work. Iron production can be increased by a simultaneous reduction in the coke charge and a planned addition of carbide. Such flexibility of melting capacity, while retaining satisfactory iron temperature cannot be obtained by any other practice. The same process is also used to shorten the time needed to collect the iron for large castings.

Figure 3 shows the intentional alteration of cupola output by a reduction of the coke charge from 14 to 10 per cent with simultaneous addition of 2 per cent carbide. Average production per hour in the first and third periods was 5.1 tons compared to 6.7 tons per hour during the periods when carbide was used, an increase of 31 per cent in output.

ADVANTAGES OF EUTECTIC CARBIDE

Foundry experience and laboratory investigations have amply demonstrated that the eutectic calcium carbide of low melting point has the following advantages for use in acid cupolas when compared to regular carbide:

1. A rapid rise of metal temperature as soon as the carbide reaches the combustion zone.
2. 2 per cent carbide produces iron 70 to 90 degrees higher in temperature with the use of less coke.
3. Complete utilization of the carbide with no residue left in the coke bed.

The question immediately comes up as to why the high melting regular carbide is useful in basic cupolas while only low melting carbide is fully efficient in the acid furnace. The explanation lies in the ready solubility of calcium carbide in basic slags. Calcium carbide dissolves easily in basic slags, the solubility improving as the calcium oxide content of the slag is increased. It appears that carbide starts to dissolve as soon as slag is formed in the melting zone of the basic cupola. When the carbide reaches the coke bed it is dissolved by the slag running over it.

Metal Oxide Reduction

The carbide taken up by the slag reduces any metal oxides present and aids in desulfurization of the iron. Carbide which is not needed for this reaction burns in the tuyere zone and contributes the greater part of the temperature rise.

Calcium carbide is not readily soluble in acid slags, and as the slag in an acid cupola cannot dissolve the carbide, material which is in itself sufficiently reactive must be used in these furnaces. The special carbide with low melting point fulfills these requirements as the temperature at which the carbide eutectic melts is in the range reached in the combustion zone of the cold blast acid cupola.

As soon as the particles of carbide reach the coke bed and start to melt, combustion of the carbide begins. The heat generated by this combustion causes the carbide particles to melt rapidly, and the liquid carbide burns vigorously as it descends into the tuyere zone.

The reactions involved are:

	Btu/Lb CaC_2
$2\ CaC_2 + 3\ O_2 = 2\ CaO + 4\ CO$ −382 kcal.	−5370
$2\ CaC_2 + 5\ O_2 = 2\ CaO + 4\ CO_2$ −650 kcal.	−9130

The calcium oxide enters the slag. Carbon dioxide and monoxide, of course, join the products of combustion. The carbide is completely consumed by these reactions and there is no direct metallurgical effect. The only effect of the combustion is the formation of a shallow zone of high temperature, slightly above the level of the tuyeres. The addition of 2 per cent carbide yields a maximum temperature of about 3275 F (1246 C) in the melting zone.

Acid Cupola Fuel

In the acid cupola, the special carbide serves as an efficient fuel generating extra heat in the combustion zone of the cupola. As the temperature in the coke bed of the operating cupola normally exceeds 3000 F (1649 C), the special low melting carbide melts as it reaches the upper part of the coke bed. The droplets of molten carbide then burn as they pass through the combustion zone, generating extra heat.

As previously mentioned, the main effect of the combustion of carbide is the formation of a shallow zone of elevated temperature slightly above the cross-section at the tuyeres. The increased temperature in the coke bed yields higher iron and slag temperature and an increase in the carbon and silicon contents of the iron. Use of carbide permits a reduction in the coke charge introducing less sulfur and resulting in higher melting rates. Molten calcium oxide formed by combustion of carbide is a highly reactive flux promoting slag fluidity and minimizing difficulties from bridging or other operating troubles.

The experienced cupola operator will recognize at once that many of these results are similar to the benefits obtained by use of preheated air for the cupola blast. Indeed, the use of carbide does permit the operator of a cold blast cupola to obtain most of the advantages inherent in hot blast operation.

Use of carbide in the acid cupola does not result in appreciable desulfurization of the iron as the acid lining does not permit a desulfurizing basic slag. The calcium oxide formed by combustion of the carbide must be allowed for by a reduction in limestone to yield a normal acid slag. As the calcium content is about 50 per cent greater than that of limestone, the usual 2 per cent addition will replace about 3 per cent of stone. A reduction in the coke charge will of course yield iron somewhat lower in sulfur, since the sulfur in the coke is responsible for the increase resulting from remelting in the acid cupola.

PRACTICAL APPLICATIONS

Following the experience of the previously mentioned plant in the melting of malleable iron and steel castings, the carbide melting process, was rapidly accepted for the melting of gray iron. In West Germany, calcium carbide is today regularly used in more than 150 foundries. About half of these use it in their entire melt. The rest use it to obtain high temperature at the beginning of the cupola heat, to compensate for shutdowns, to temporarily increase melting capacity and in the production of iron of special quality such as that used in making ductile iron castings.

Cupola Benefits Determination

To determine whether a given cupola operation can benefit by the use of carbide, one or two experimental heats are melted. At the start data are collected concerning normal melting capacity, iron temperature and the composition of the iron and slag. Following this, tests with calcium carbide are run. Four per cent is used on the coke bed and on the first charge and 2 per cent for the second through the sixth charge omitting the limestone. No other changes are made in the mixture. If the furnace reacts well, carbide is added without further delay. If the coke charge is to be lowered, regulation of the stone additions and blast are necessary. The coke input is reduced the next melting day, and the blast volume adjusted to obtain the best temperature and melting rate.

Carbon and Silicon Adjustment

In order to adjust carbon and silicon to normal values further corrections are made to the mixtures as indicated by the iron analysis. Generally within two melting days, and without unusual troubles or production loss, sufficient data to indicate the technical advantages as well as preliminary data for economic evaluation of the material are obtained. If a foundry decides to adopt the carbide process, the amount necessary will be determined during the following melting days. The amount of carbide charged depends on the conditions. The average is about 2 per cent, but in some cases this can be reduced to one per cent or increased to 3 per cent. As soon as the optimum conditions for the new melting process are determined, and the charging crew has become accustomed to the changes, melting will proceed as smoothly as before the change.

Table 1 shows the results obtained in nine different plants producing different foundry products. Line 1 in each case indicates the results determined by observation of the original practice. In the case of *A*, lines 2 and 3 list transition values, while line 4 indicates the final results obtained. For *C* an intermediary step is shown. For the rest of the products intermediate values were omitted, line 2 indicating the results obtained after adopting the use of carbide.

Benefits From Calcium Carbide

Table 2 provides an evaluation of the data in Table 1, indicating the various types of benefits obtained from the use of carbide. A check mark appearing under any particular category such as "Higher

TABLE 1 — CHANGE FROM COLD BLAST CUPOLA TO MELTING WITH CALCIUM CARBIDE

		MIXTURES								IRON								SLAGS							
								Calcium[a]																	
A-G: Gray Iron For	Cupola Dia., in.	Chg. Wt., Lb	Pig Iron, %	Scrap Iron, %	Steel Scrap, %	Revert Scrap, %	Chg.[a] Coke, %	Carbide, %	Limestone,[a] %	Melting Rate, tons/hr	Temp.,[b] F	Temp.,[b] C	Analysis, % C	Si	Mn	P	S	Analysis, % SiO_2	CaO	Al_2O_3	Fe_2O_3	FeO	MnO[c]	S^d	CaO / SiO_2
A. Enameled Ware	32	880	40	28	—	32	14	—	4	4.3	2516	1380	3.32	2.75	0.52	0.80	0.132	51.9	27.3	8.1	2.2	5.9	3.4	0.13	0.52
	32	880	40	28	—	32	10	2	1	5.4	2606	1430	3.50	2.88	0.60	0.81	0.097	53.4	28.9	8.8	0.5	3.8	3.1	0.14	0.54
	32	880	36[e]	34	—	30	10	2	1	5.5	2624	1440	3.47	2.69	0.58	0.75	0.108	54.5	28.6	8.2	0.6	3.5	3.3	0.12	0.52
	32	880	36[e]	34	—	30	10	1.8	2	5.5	2606	1430	3.45	2.70	0.53	0.77	0.103	51.0	34.3	9.0	0.2	2.3	1.9	0.30	0.67
B. Radiators	36	1100	30	42	—	28	15	—	5	5.0	2552	1400	3.35	2.68	0.68	0.80	0.140	49.0	31.9	9.1	0.8	3.6	4.0	0.21	0.65
	36	1100	30[e]	45	—	25	11	2	3	6.3	2678	1470	3.48	2.61	0.66	0.83	0.106	47.2	37.0	8.6	0.0	2.9	2.4	0.29	0.78
C. Machine Tools	40	1540	35	33	5	27	12.5	—	5	7.2	2570	1410	3.40	1.82	0.68	0.40	0.110	46.9	34.0	12.8	0.0	3.0	2.6	0.40	0.72
	40	1540	35	33	5	27	10	2	2	8.6	2678	1470	3.53	1.90	0.70	0.39	0.090	48.1	36.1	10.6	0.0	2.7	2.0	0.44	0.75
	40	1540	30	34	12	24	11	1.5	2.5	7.8	2660	1460	3.44	1.85	0.63	0.35	0.095	47.2	36.6	10.9	0.0	2.5	1.7	0.41	0.77
	40	1540	40	29	10	21	13	—	5	7.2	2588	1420	3.23	1.55	0.80	0.27	0.113								
	40	1540	40	29	10	21	10.5	2	2	8.3	2678	1470	3.41	1.66	0.88	0.30	0.105								
	40	1540	35	27	18	20	11	1.5	2.5	7.9	2642	1450	3.21	1.52	0.85	0.25	0.100								
	40	1540	40	30	20	10	13	—	5	7.2	2588	1420	3.05	1.37	0.88	0.22	0.108								
	40	1540	40	30	20	10	11	2	2	7.9	2642	1450	3.18	1.40	0.90	0.22	0.098								
	40	1540	32	28	30	10	11.5	2	2	7.7	2660	1460	3.10	1.29	0.91	0.18	0.101								
D. Automobile Cylinders	40	1320	50	10	5	35	13	—	6	6.8	2588	1420	3.20	2.18	0.74	0.40	0.110	44.3	36.9	10.5	0.0	3.1	2.8	0.30	0.83
	40	1320	40	12	15	33	11	2	3	7.6	2678	1470	3.25	2.15	0.72	0.25	0.089	46.6	37.5	8.2	0.0	2.9	2.3	0.32	0.80
E. Centrifugal Pipe	32	1100	50	20	—	30	13.5	—	4[h]	4.4	2552	1400	3.32	2.06	0.78	0.40	0.103	46.1	31.8	14.0	0.3	2.6	3.2	0.38	0.69
	28	880	45[e]	27	—	28	10	2	2[h]	4.5	2642	1450	3.49	2.01	0.81	0.43	0.072	44.7	35.6	13.3	0.0	2.1	1.8	0.53	0.80
F. Piston Rings	28	660	60	—	—	40	16	—	5[h]	3.1	2588	1420	3.52	2.10	0.72	0.62	0.090	42.1	34.4	17.5	0.0	2.0	1.6	0.50	0.79
	24	550	60[e]	—	—	40	11	3	2[h]	3.2	2714	1490	3.77	2.16	0.75	0.63	0.062	42.0	37.3	15.8	0.0	1.2	1.3	0.55	0.89
G. Ingot Molds	52	2200	40[f]	60[g]	—	—	12.5	—	3	12.7	2516	1380	3.53	1.80	0.48	0.08	0.095	50.2	29.0	7.9	1.3	6.0	3.8	0.20	0.58
	52	2200	40[f]	60[g]	—	—	10.5	1	2.5	14.3	2534	1390	3.60	1.85	0.46	0.08	0.081	49.7	34.4	7.4	0.5	2.9	2.1	0.32	0.71
H. Malleable Iron Fittings	36	1320	30	—	25	45	18	—	3[i]	4.6	2570	1410	2.95	0.63	0.45	0.07	0.22	52.3	26.6	9.3	1.5	5.0	2.8	0.12	0.51
	36	1320	20	—	35	45	12.5	2.5	—[i]	6.6	2696	1480	3.02	0.65	0.42	0.06	0.20	52.8	31.2	7.3	1.1	4.2	2.7	0.15	0.59
J. Steel Castings	40	1760	35[f]	—	25	40	19	—	7	5.0	2588	1420	3.10	1.08	0.40	0.05	0.14	51.1	28.5	11.0	0.3	5.3	3.5	0.14	0.52
Premelted Iron For Converter	40	1760	20[f]	—	40	40	13	2	5	6.9	2678	1470	3.18	1.20	0.45	0.05	0.09	50.5	31.8	9.5	0.3	3.2	3.0	0.20	0.63

NOTES:

a) % of iron charge = 100 (West German Foundry Coke with one % sulfur).
b) Temperature: Daily average.
c) The valences of the oxygen were not determined.
d) The content of sulfate in the slags is low (rarely above 0.1% SO_3).
e) To correct the increasing silicon content of the iron a portion of the pig iron charged was low silicon.
f) Exclusively Hematite pig iron.
g) Broken ingot molds.
h) A Bauxite addition increases the Al_2O_3 content of the slag to improve its fluidity.
i) Calcium sulfate is added to increase the sulfur content of the iron and to improve machinability (treating and tapping).

TABLE 2 — EVALUATION OF CARBIDE EFFECTS FROM TABLE 1

A-G: Gray Iron For	Higher Temp.	Lower Coke	Higher Tons /Hr	Iron Lower S	Iron Higher C	More Steel
A. Enameled Ware	√	√	√	√	√	—
B. Radiators	√	√	√	√	√	—
C. Machine Tools	√	√	√	√	→	√
D. Automobile Cylinders	√	√	√	√	→	√
E. Centrifugal Pipe	√	√	—	√	√	—
F. Piston Rings	√	√	—	√	√	—
G. Ingot Molds	—	√	√	√	—	—
H. Malleable Iron	√	√	√	—	→	√
J. Steel Castings	√	√	√	√	→	√

Temperature" or "Lower Coke" indicates benefit from the use of carbide.

When difficulties are experienced with the iron, the use of carbide will always be helpful. Higher carbon and increased temperature improve fluidity, while increased melting capacity and lower sulfur result from the lower coke consumption. Experience of several years shows that most cold blast cupolas melting steel-free mixtures produce excellent iron with 10 per cent coke and 2 per cent carbide.

Cost Advantage

The carbide melting process has rapidly become popular because of its cost advantages. It is difficult to set up rules for determining the savings obtained from use of calcium carbide, as the advantages which can be utilized depend somewhat on the conditions in an individual plant. Most calcium carbide is used in producing gray iron castings, a field in which costs are extremely important and it has been found the advantages invariably outweigh the costs involved.

The lower overall costs resulting from use of carbide come from:

a. Improved Iron Quality. Better fluidity results from higher temperature, increased carbon and lower sulfur, therefore less rejects.
b. Increased Melting Capacity. Shorter heats and elimination of overtime work.
c. Reduced Coke Consumption.
d. More Economical Mixtures. Less pig iron and more iron or steel scrap can often be used.

CONCLUSIONS

Since 1956 a special calcium carbide of eutectic composition containing roughly 70 per cent carbide and 30 per cent lime has found wide use in Germany as an addition to acid cold blast cupolas. This material melts at about 2970 F (1632 C), a temperature existing in the melting zone of the average cupola, and burns in the coke bed causing a shallow zone of high temperature directly above the tuyeres.

Use of the special carbide in the amount of about 2 per cent of the iron charge yields increased metal temperature, higher carbon in the iron and reduced oxidation of silicon. Use of carbide usually permits lowering the coke charge resulting in a decided increase in melting rate and a reduction in the sulfur content of the iron.

Carbide is used by some foundries to increase the temperature of the first iron at the beginning of the cupola heat, to minimize temperature loss resulting from planned shutdowns and to regulate the melting rate of the cupola to meet varying demands for metal.

Depending on local conditions in individual foundries, the use of carbide permits savings from a reduction in coke usage, elimination of delays and overtime wages and use of more economical mixtures containing less pig iron and increased amounts of iron or steel scrap.

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BRONZE VALVE VERTICAL GATING IN SHELL MOLDS

by F. E. Murphy, G. J. Jackson and R. A. Rosenberg

ABSTRACT

A gating system has been devised for casting 85-5-5-5 and *M* Metal pressure containing parts in shell molds. The gating system was developed by experimentation with mold halves covered with glass; the system indicated as best by this test was then used in regular molds under rigorous inspection and constant monitoring of melting and pouring conditions.

The gating system thus developed is one of the saxophone type, with a well at the bottom of a tapered sprue and enlarged upgates to reverse the direction of flow. Provisions are made for the use of a strainer core, and storage heads are added to compensate for deformation of the mold. The efficiency of the system has been demonstrated in shop use by a rejection rate less than 3.0 per cent.

INTRODUCTION

This paper comprises ten or more years experience in producing bronze castings in shell molds at the authors' company. It is not the purpose of the authors to defend or recommend vertical rather than horizontal gating for shell molds. Each method has its shortcomings and advantages, which are dependent on requirements differing for individual foundry operations.

In the vertical pouring of brass and bronze alloys in shell molds, nearly all the difficulties associated with the production of smooth, pressure tight, and dimensionally accurate castings can be attributed to improper gating. For this discussion, gating includes the arrangement of the patterns on the plate, and the sizes and shapes of the pouring basin, downgates, runners, upgates and ingates.

LITERATURE REVIEW

Early Practical Experiences in Gating Shell Molds

Initial training of the authors in the shell molding was under the supervision of the inventor of the process, Dr. Johannes Croning. Quite naturally, he exerted great influence on the design of the first shell mold gating systems at the authors' company. Up to that time shell mold gating practices in Europe had not been adopted to the casting of pressure vessels. Experience quickly revealed that casting pressure tight bronze products presented its own peculiar problem. Also, years of practical experience in horizontal gating for 85-5-5-5 and composition *M* Metal in green sand molds influenced us to choose this method for our initial gating systems. However, with the passage of time, vertical gating was developed and adopted as standard practice; this greatly reduced losses to where scrap can now be maintained at less than a 3.0 per cent level.

Experimental Work on Vertical Gating Using Regular Molds

The first castings poured in vertical shell molds were gated directly from the downgate. Figure 1 shows a typical arrangement with simple pouring cup and untapered cylindrical sprue from which the castings filled through reversed ingates. Jets of metal entered the casting cavity at high velocity, penetrating the cores and mold walls, causing poor surface finish and producing castings which, in many cases, were inferior to those made in green sand.

By examining Fig. 1, there are a number of things seen to be obviously wrong. First, the shape of the pouring cup introduces a swirling action to the metal, generating a vortex; the cup is too shallow to prevent splashing, and is not effective in retaining slag. The initial corrective action was to enlarge the basin and make it more cup shaped, and to reduce the outlet. However, these changes made the swirling action worse, while the restricted bottom orifice increased the velocity of the metal and drew slag down into the gate.

In an effort to control or nullify the swirling action introduced by the pouring basin, the downgate was changed from a circular to a rectangular cross-section. However, since the falling metal stream did not immediately fill the basin and so contact the sidewalls, before filling the downgate, the swirling action was not checked soon enough to prevent some slag entering the mold.

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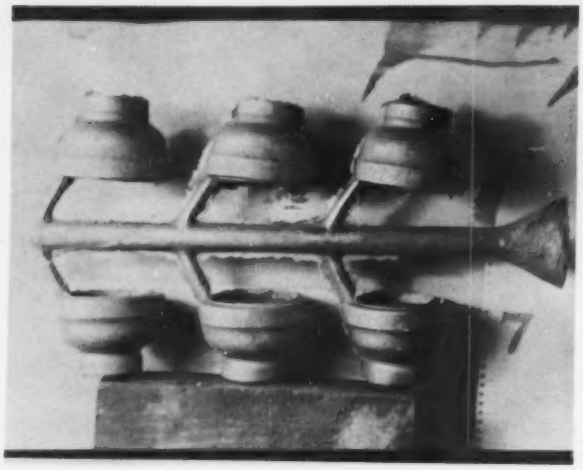


Fig. 1 — One of the early gating systems. The cone shaped basin and untapered cylindrical downgate did not control the metal. Ingates directly from the sprue caused erosion, as noted.

Minimizing Velocity of Metal

To minimize the effect of velocity, the ingates were tilted upwards to form a *Y* shaped arrangement, but when a number of molds were poured from a single ladle, many of the castings contained shrinkage. Next, lateral runners were used with bottom ingates. Since the ingates were at the lowest part of the casting and were usually tapered from a rather heavy runner, there was considerable jetting action with resultant turbulence. This has been fully described in the literature.[1] At one time, it was felt that the jetting action was due to the restriction of the ingate. Therefore, a ball expansion chamber was inserted between the runner and the casting. This tended to lessen but not eliminate the turbulence.

However, by increasing the mass of liquid metal below the casting shrinkage developed at the ingate area. A broad, thin ingate, approaching the dimensions of a kiss gate, was tried on the premise it would solidify before the casting, but this also proved unsatisfactory. It was concluded that gating shell molded castings from the bottom did not ensure a pressure tight casting.

The next step was to gate from the top so that a heavy lateral runner would act as a riser to the casting. However, the turbulence generated as the bronze alloy cascaded around the core was most harmful. The erosive effect on the core was intensified, and the displaced air, seeking to escape through the top ingate, was readily ingested into the stream and remained entrapped in the solidified casting; so this method was rejected.

Research being performed at the time showed the advantage of using a tapered sprue. Swift et al[2] noted that "The sprue cross-section should decrease in proportion to the increase in velocity so that no separation of the liquid from the sprue wall and no suction or gas aspiration tends to occur." Investigations confirmed the efficacy of matching the taper of the downgate to the natural shape of the falling stream. By confining the metal in a form-fitting tube, turbulence was lessened and the aspiration of air into the stream was prevented. The rectangular cross-section was retained in the tapered sprue.

The use of the tapered section demanded a choke at the base to insure that the downgate remained full and to prevent the ingestion of air through the pouring basin. It also dictated the size and shape of the pouring basin and, since we now had a pressurized system, prevented ingating directly from the downgate.

This led to the development of a "downgate-upgate" or reverse flow system ("Saxophone" gates) where the forces generated in the falling metal could be controlled or dissipated by reversing the direction of flow, and where the static head of the upgate would gradually compensate for the metal in the downgate, thus resulting in quiet, unpressurized metal entering the mold cavities. This system has the disadvantage of requiring a larger ratio of gate to product than

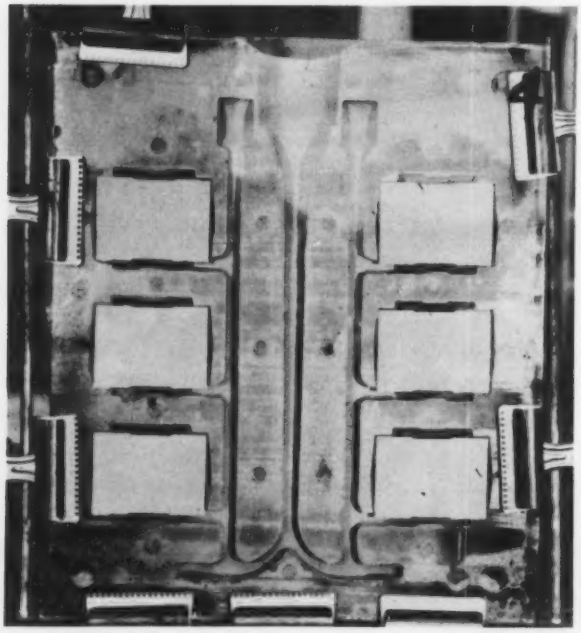


Fig. 2 — Intermediate design of the reverse flow system, shown ready for pouring study. Note the streamlined construction of the gates and the generous radius at all corners.

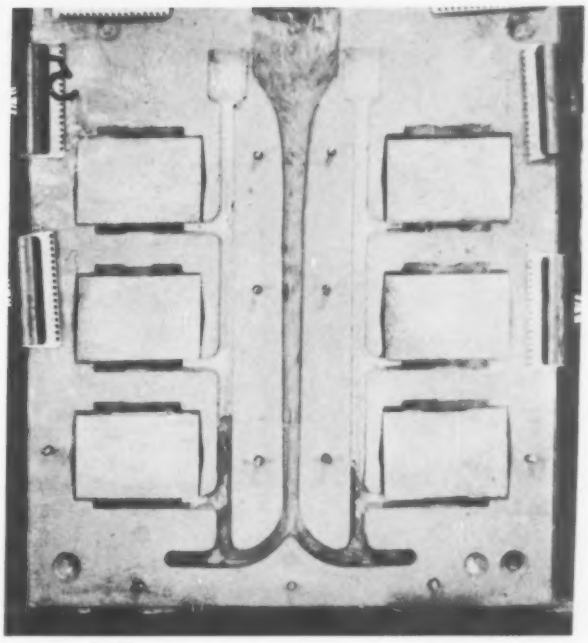


Fig. 3 — The glass faced mold without a strainer core is shown ⅓ full of water. Turbulence; the unequal levels of liquid in the upgates are evident.

the direct flow system. Although the yield was lower, so was the scrap, which meant a net gain. Figure 2 shows one form of this reverse flow system.

Experimental Studies Using Glass-Covered Mold Holders and Water

These gating design studies were facilitated by observing the flow characteristics when a glass plate or plastic sheet was clamped tightly against the face of a half mold. Cores were cut in half along the plane of the mold parting line and coated with a moisture resistant film. The face of the mold was greased to ensure intimate contact with the glass, care being taken so that the mold surface of the ingates, runners and cavities retained their permeability. The mold was placed in a vertical position and water was poured into the basin. The flow was readily observable through the glass and the defects of the system could be examined.

Minor corrective changes could be made immediately by filing away parts of the mold or by building up areas with modeling clay. High speed motion pictures aided in the interpretation and recording of the flow characteristics of the various gating systems.

Although the work of Swift et al[2] was performed on horizontal gating, their basic principles apply equally well to vertical gating. They found that water gave a satisfactory approximation of the flow characteristics of molten bronze. Admittedly, water is not a substitute for molten metal and, in the case of drossy type alloys, this method will not be completely satisfactory. However, dye can be introduced into the water to show the presence of static areas, regions of turbulence or the generation of eddy currents in the stream, and to check the effectiveness of corrective changes. The introduction of solids of varying types, shapes and densities into the water simulated the action of dross, slag or sand in the system and, for this application, indicated the need for a strainer core.

Under the best melting and ladling conditions, nonferrous metal will contain some dross. As the pouring ladle is emptied, the proportion of dross to liquid increases greatly, particularly where 12 to 15 molds are poured from one ladle and the ladle is tipped back and forth a number of times. Even with continual skimming of the metal some dross is usually missed. Besides the efficient skimming action of the strainer core it also minimizes somewhat the variation in velocity head caused by pouring from various heights as the ladle is emptied. The bottom castings in a vertical mold are not as smooth as the upper castings. As the metal head increases, penetration increases. To partially offset this, the lip of the ladle should be kept as close to the pouring basin as possible, which will minimize the variation in pressure head.

Strainer Core

It is easy to perform all of the proper operations in the laboratory, but not so easy to adapt all of them to production. The strainer core was one extremely helpful item that was fully practical and helped considerably in off-setting some of these difficulties. Logically, any strainer should be placed at the base of the sprue, but space limitations on the pattern plate plus the additional labor and care to insert a strainer during mold assembly forced a compromise, and the strainer was located at the bottom of the pouring cup. The cup was deepened and made with a shoulder into which a strainer core could be dropped into place in the assembled mold at the pouring station.

The conventional strainer with round holes divided the stream into a number of jets, which caused considerable turbulence in the downgate. The strainer was redesigned with narrow, concentric slots which delivered sheets of molten metal capable of reblending with a minimum of agitation.

As noted, streamlining the system, particularly at the base of the downgate, had lessened turbulence but had increased the velocity of the metal. The metal was driven into the upgates to a height much above the level in the cavities, often to the extent that upper castings started to fill sooner and at a slower rate than had been anticipated. Note in the photographs of Figs. 3 and 4 the turbulence and entrained air in the gating system and the agitation

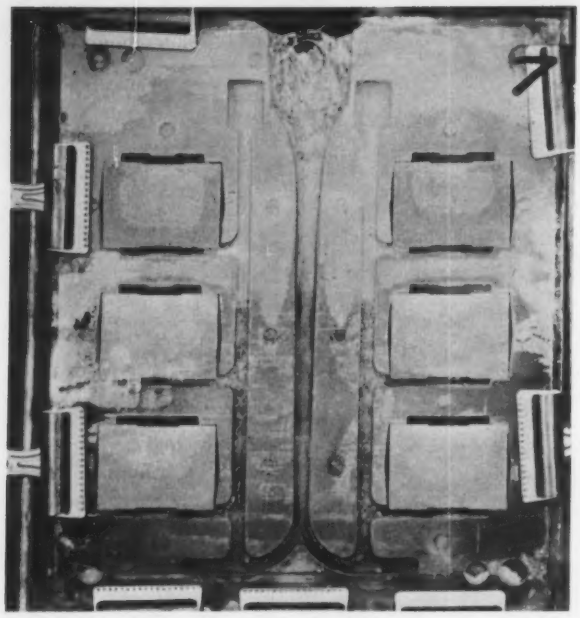


Fig. 4 — Seconds later, with the molded half filled; agitation and entrainment of air has increased and the turbulence within the casting cavity is noticeable.

within the casting cavity. This caused cold shuts or misruns, particularly if the pressure head varied due to erratic or intermittent pouring.

The choke at the base of the downgate was designed to be small enough to control the flow into the bottom castings when there is, at first, differential pressure on the upstream side, and yet be large enough to ensure full flow in the later phase when the weight of metal in the upgate counteracted the downgate pressure. A formula was devised as a guide in the laboratory for choking the stream, but many of our pattern plates have chokes which were altered empirically in the foundry. Figure 5 shows the chart based on the rate of flow in lb/sec for various choke areas. From production records, weights of castings and time studies, a good average pouring time was obtained. Hence it was easy to predict a desirable choke area. Figure 6 is a chart of the rate of rise through the same choke areas, and was used to refine the above determination as the number and size of pieces in a mold varied.

Well Development

Other studies aided in developing a well at the base of the downgate. Unfortunately, there was insufficient layout space on the pattern plate for a well of the dimensions recommended. The glass faced mold was valuable in arriving at a design, which for most patterns completely fulfills requirements. Minor adjustments were necessary on certain atypical layouts, but in each case these were checked out by studying a water flow pattern. The basic form is a 1.0 in. diameter cylinder with the top slightly domed to prevent entrapment of air. The lateral runners are placed slightly below the center of the chamber so there is a definite well below them.

It must be understood there will be areas of turbulence and air bubbles in the water which flows first through the system. No way was found to eliminate this. The measure of the effectiveness of good design in the gates is the speed with which this initial turbulence is purged from the liquid. If the metal following is quiet and free of air, the castings will most likely be sound. At the end of each bottom runner an enlarged pocket is provided to entrap and hold the first metal.

Most jetting action takes place as the metal enters the upgates. To control this condition the upgates are enlarged in cross-sectional areas. The ingates are nearly horizontal to prevent gravity flow of metal from the castings after the pressure surge of pouring has ceased. In order to prevent the ingates from freezing too quickly, they are enlarged as much as possible, in some cases the corner is rounded off the core print at the ingate to increase the mass of metal at this point.

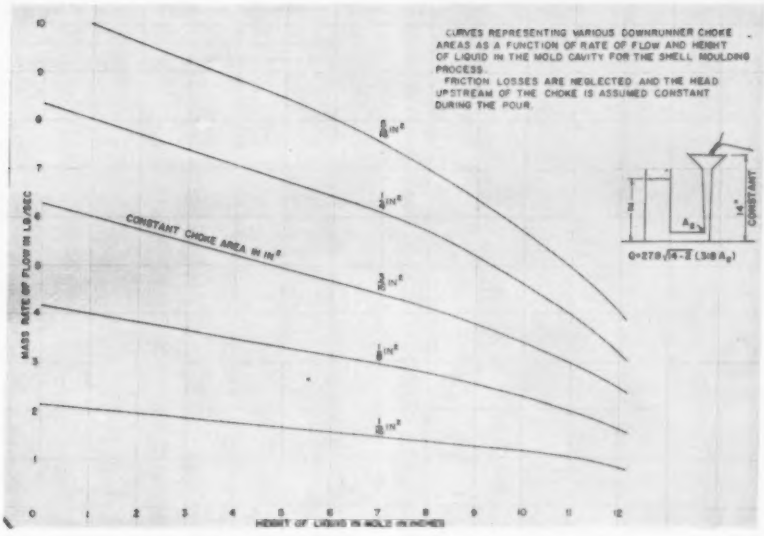
The series of photographs, Figs. 7 through 12, show water flow patterns in this improved system. Figures 7 and 8 illustrate how the system, without a strainer core, is purged of initial turbulence and remains free of agitation or inspiration of air. Figures 9 and 10 show that although the slotted strainer generates some turbulence, the design of the well at the sprue base has quieted the metal. Figures 11 and 12 demonstrate that even a properly designed well cannot purge air entrainment from the system caused by the round holes of conventional strainers.

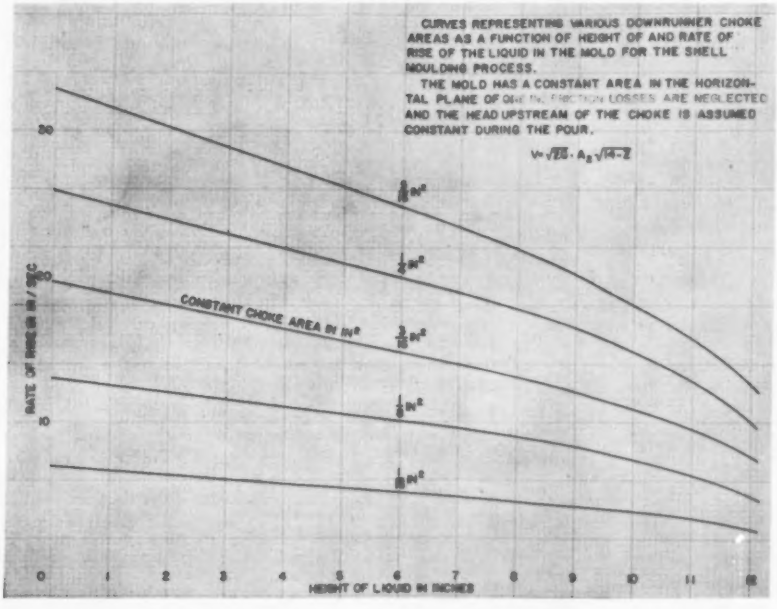
This series of photographs also indicates that if clean metal can be assured, there are flow advantages in pouring without a strainer, but if a strainer core must be used, the slotted type is more efficient than the round hole type.

Use of Storage Heads to Overcome Casting Shrinkage Due to Mold Deformation

Having developed the gating system to this point, despite precautions, a slight deflection in the mold wall, caused by softening of the resin under the heat of the molten metal, resulted in shrinkage of the casting. This hot deformation took place after pouring had stopped, and caused an increase in the size of the casting and volume of the cavity at a time when the gating system had begun to freeze and no liquid was available for feeding.

To overcome this deficiency, a storage head was placed at the top of the upgates and the metal was allowed to continue passing through the gating system after all the cavities had been filled. A "rule of


CURVES REPRESENTING VARIOUS DOWNRUNNER CHOKE AREAS AS A FUNCTION OF RATE OF FLOW AND HEIGHT OF LIQUID IN THE MOLD CAVITY FOR THE SHELL MOULDING PROCESS.
FRICTION LOSSES ARE NEGLECTED AND THE HEAD UPSTREAM OF THE CHOKE IS ASSUMED CONSTANT DURING THE POUR.
CONSTANT CHOKE AREA IN IN²
MASS RATE OF FLOW IN LB/SEC
HEIGHT OF LIQUID IN MOLD IN INCHES
14" CONSTANT
Q=278√(4-Z)(3/8 A₂)


CURVES REPRESENTING VARIOUS DOWNRUNNER CHOKE AREAS AS A FUNCTION OF HEIGHT OF AND RATE OF RISE OF THE LIQUID IN THE MOLD FOR THE SHELL MOULDING PROCESS.
THE MOLD HAS A CONSTANT AREA IN THE HORIZONTAL PLANE OF ONE IN. FRICTION LOSSES ARE NEGLECTED AND THE HEAD UPSTREAM OF THE CHOKE IS ASSUMED CONSTANT DURING THE POUR.
V=√2G · A₂√14-Z
CONSTANT CHOKE AREA IN IN²
RATE OF RISE IN IN / SEC
HEIGHT OF LIQUID IN INCHES

Figs. 5 and 6 — Graphs used in predicting desirable choke areas in laying out gating for laboratory evaluation.

thumb" was used for the amount of metal evacuated into the storage head; this was simply an amount of metal equal to that in the upgates. This accomplished three things:

1) It kept pressure on the ingates.
2) Prevented the upgates from freezing, shrinking and forming shrinkage voids which would tend to attract liquid metal into the vicinity.
3) Made certain that the metal in the gates was hotter than that in the casting, thus promoting directional solidification.

It is to be noted that these are not shrink heads, and although their presence achieves the same results as a shrink head – that is, a sound casting – their action is not wholly that of riser.

Adapting Experimental Results and Practice

While some work was performed on calculating the dimensions of downgates, runners, upgates and ingates, the necessity for getting patterns into production has kept this work to a minimum and no formal study was recorded. Ratio gating was used with the information available in the literature serving as a guide. Fortunately, the gating system developed for one item served as the prototype for many others.

The reverse flow system or "Saxophone Gating" has been in use for many years on production items in the foundry, and has been proved valuable. The 3.0 per cent scrap rate has been consistently lower than with other systems.

Studies are still being performed to improve the design, and any new items introduced into shell

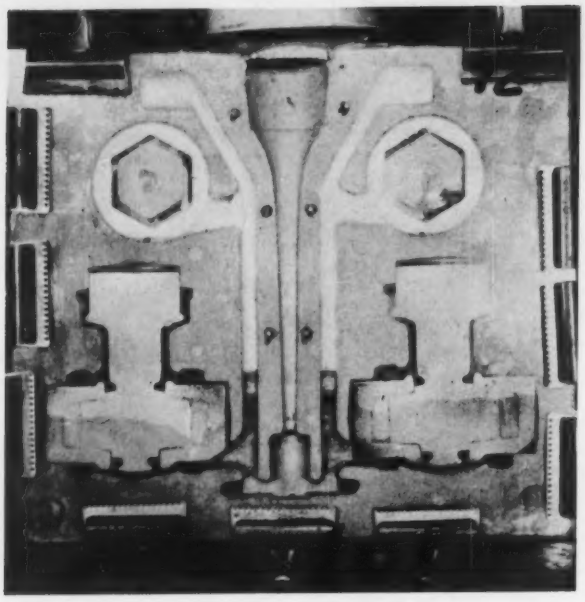


Fig. 8 — Same as Fig. 7 except with the mold half filled. The effective purging action of the well is evident.

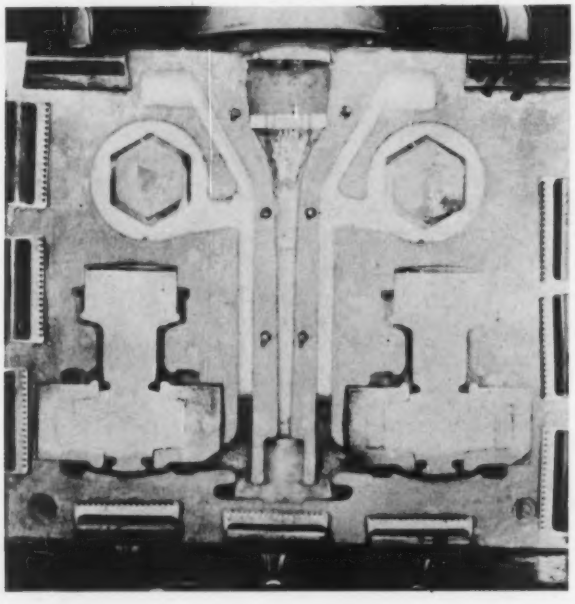


Fig. 10 — As pouring continues the sprue-base well has quieted the agitation introduced by the slotted strainer core.

Fig. 7 — Revised gating, incorporating a sprue-base well, shown without a strainer core and ⅓ full of water. Note the absence of air and agitation except in the first liquid in the upgates.

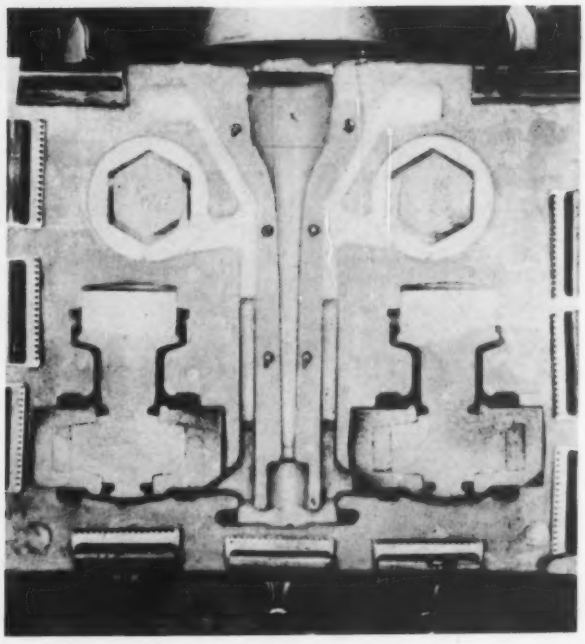


Fig. 9 — Compare with Fig. 7. The addition of a slotted strainer core has slightly increased the initial agitation.

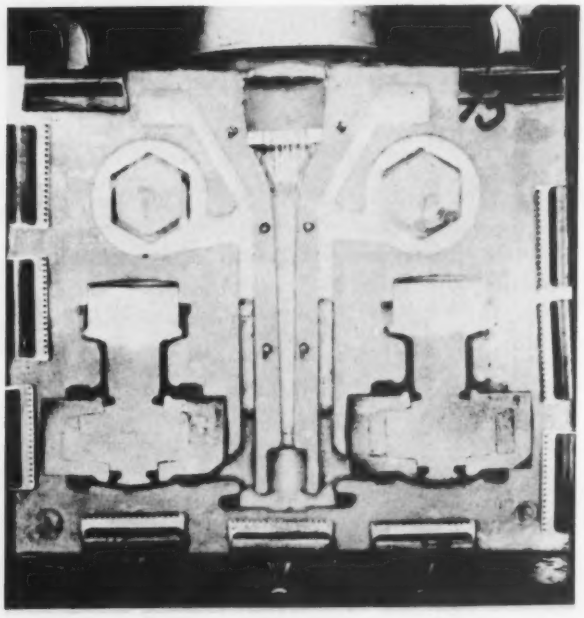
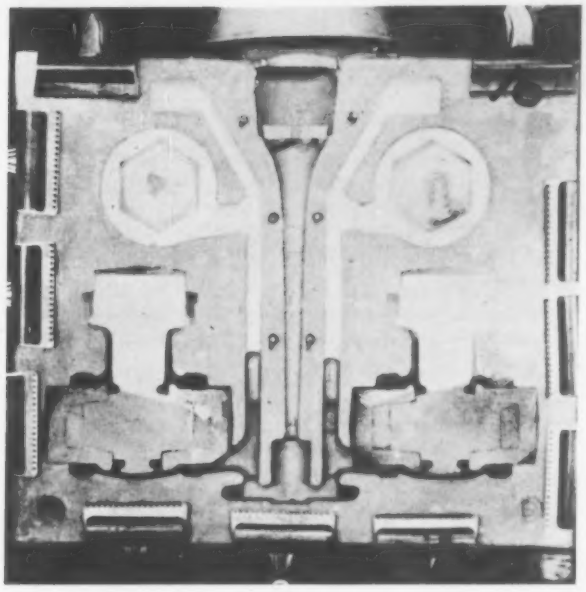


Fig. 11 — The use of a round hole strainer makes little change in the initial flow of liquid into the mold.



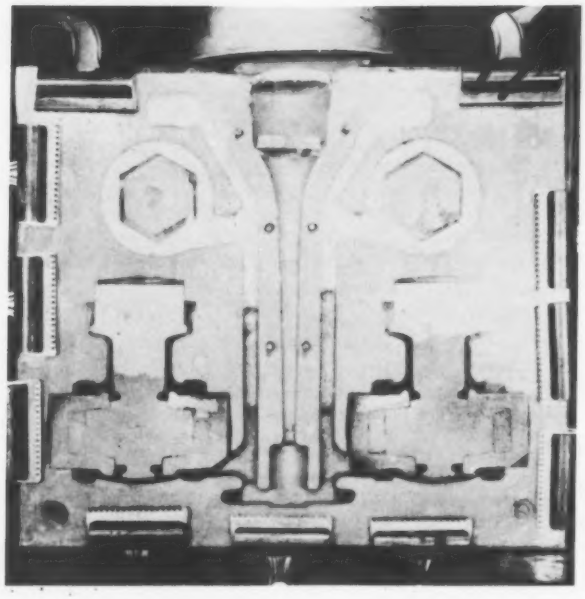


Fig. 12 — In the later stage of pouring the fine bubbles of entrained air generated by the multiple jets of the round hole strainer are still noticeable in the liquid.

molds are studied by glass faced shell molds using water-flow analysis in the laboratory before release to production. Regular spot checks on production castings are made by fracture tests and by radiographic analysis; also close control is maintained on melting and pouring conditions and on pouring temperatures since, without controls in these areas, no gating system can function properly.

SUMMARY

The results of the experimental work reported herein, and of ten or more years practical experience on gating design for shell mold castings of 85-5-5-5 and *M* Metal at the authors' company are:

1. Vertical gating has proved vastly superior to horizontal gating for making sound, clean, pressure tight castings.
2. The "Saxophone type" gate with proper shape and dimensioning of sprue-cup, downgate, catch basin, upgate, ingates and storage head can reduce the incidence of shop scrap to less than 3.0 per cent.
3. Vertical shell molds undergo an expansion due to softening of the resin under the added pressure of extra metal height, which causes a slight expansion of castings and thus increased shrinkage; this can be overcome by use of a storage head.
4. The use of half molds covered with a glass plate into which water is poured is an excellent means for studying gating systems.
5. Adaptation of the experimental work to practice proves the authenticity of the results obtained in the laboratory.

ACKNOWLEDGMENTS

The authors wish to express their sincere appreciation to the many people who participated in the development of the shell mold program over the years at the Walworth Co. They wish to thank Professor H. F. Taylor for reviewing this work and for his comments and criticism. Mr. D. Winslow aided in making illustrations and Miss R. Nelson prepared the drafts.

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2. Swift, Jackson and Eastwood, "A Study of the Principles of Gating," AFS TRANSACTIONS, *vol. 57* (1949).
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CALCINED FLUID COKE AS NEW MOLDING MEDIUM

Preliminary evaluation

by E. G. Gentry and C. L. Lear

ABSTRACT

A grain-shaped composition of high carbon content, generally referred to as fluid coke, has been produced by a new petroleum refining process. The author describes a preliminary investigation of the use of calcined fluid coke as a new molding medium,* replacing sand in green and baked molds, baked cores and shell molds and as the principal ingredient of a mold and core wash. Gray iron, bronze and aluminum castings of superior surface smoothness and grain structure have been cast in calcined fluid coke. The inert nature and low thermal expansion of calcined fluid coke are principal properties credited for advantages shown over sand.

INTRODUCTION

Foundrymen have long appreciated the desirable characteristics of carbonaceous materials as ingredients of mold and core mixtures and in mold and core washes. The addition of sea coal to molding mixtures is universally practiced. Certain proprietary products of high carbon content are used as coatings for molding sand. Pulverized carbon and graphite may be incorporated into mold and core mixtures or applied as a wash. Solid carbon blocks have been machined to form semi-permanent molds. Some work has been done with crushed foundry coke as a molding material.**

In most of all experiences with materials of high carbon content in casting operations, three features are outstanding:

1. Carbon establishes a reducing atmosphere in the mold.
2. Carbon contributes lower thermal expansion to the mold mixture.
3. Carbon resists wetting by molten metal and tends to resist metal penetration. This paper describes experimental work carried out with a material which could be loosely defined as a carbon sand, and which differs substantially from previously known carbon sands by having higher real density, higher grain hardness and better grain shape.

A petroleum refining process has been developed by a research and engineering company whereby residual petroleum oils are further refined to yield gasoline and coke. This refining process is known as the Fluid Coking Process, the term being descriptive of the use of fluidized solids in the process, and the coke so produced is generally referred to as fluid coke.

Fluid coke, as produced at the refinery, is essentially carbon, consisting of hard, round to subangular grains, similar in grain size and distribution to foundry sands, and is available in large quantities. To remove all volatile hydrocarbons, raw fluid coke was calcined at approximately 2800 F (1538 C). It was noted that the calcining treatment increased the real density of the grains, and it was later determined that calcining improved the thermal stability of the fluid coke. Table 1 shows a typical inspection of the calcined fluid coke evaluated in this report, and a typical screen analysis is given in Table 2. These characteristics of calcined fluid coke indicated it

*U. S. Patents No. 2,830,342 and 2,830,913.

**Described by Harry W. Dietert in "Processing Molding Sands," Charles Edgar Hoyt Annual Lecture, AFS TRANSACTIONS, *vol. 62*, p. 1 (1954).

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should be tried as a molding medium for the casting of metals.

A considerable amount of experimental work was carried out to evaluate calcined fluid coke as the principal molding material, replacing sand in green molds, baked molds, baked cores and shell molds for casting of both ferrous and nonferrous metals. Pulverized calcined fluid coke was also tested in mold and core washes. Due to the pioneering nature of this work, most of these experiments were conducted in actual foundry production and evaluated by observation. Therefore, the examples reported in this paper were chosen for completeness of data, photographs and laboratory support, rather than as examples of preferred technique in the use of calcined fluid coke. All work reported in this paper was conducted with calcined fluid coke, but, to permit a less cumbersome terminology, the material will be referred to hereafter in this report simply as fluid coke.

TABLE 1 — TYPICAL INSPECTION OF FLUID COKE TESTED

Carbon, Wt. %	97.7
Sulfur, Wt. %	2.0
Volatile, Wt. %	nil
Apparent density (gm./cc)	1.11
Lb/gallon	9.26

NOTE: Carbon, sulfur and volatile contents of fluid coke vary with origin of petroleum stock and processing technique.

TABLE 2 — TYPICAL SCREEN ANALYSIS OF FLUID COKE AND TEST SAND

	Per Cent Retained on	
U.S. Sieve No.	Fluid Coke	New Jersey 60 Silica Sand
6	—	—
12	—	—
20	0.2	0.2
30	0.4	0.4
40	2.4	3.9
50	12.6	17.2
70	27.7	34.9
100	37.9	30.6
140	14.2	8.9
200	3.8	2.5
270	0.6	0.8
Pan	0.2	0.6
Clay	None	0.5
A.F.S. Fineness No.	67.5	63

GENERAL TEST PROCEDURES

The tests were set up to provide an early appraisal of fluid coke in practical foundry applications. Castings were produced with fluid coke molds and cores, and were compared with similar castings produced by conventional sand practice. To the extent possible with production equipment, these tests were conducted in a manner allowing the mold and/or core composition to be the only variable. The castings intended for comparison were poured side by side, generally from the same ladle, and were then examined for any differences in surface finish and soundness.

Tests of Fluid Coke in Green Molds

To evaluate fluid coke as a green mold material, fluid coke mold mixtures were prepared in a laboratory-size mixer, and thereafter, handled with regular foundry production equipment. Jolt-squeeze molding machines were used to make all molds. Patterns for castings of gray iron, bronze and aluminum were selected from current production work. In each case, molds of the sand mixture regularly used by the foundry were poured alongside the test mold as a control.

Table 3 lists fluid coke molding mixtures and corresponding control sand mixtures, showing their physical properties, and identifying the type of metal cast in each; the metals cast being gray iron, bronze and aluminum. Each pair of molds was rammed, poured and shaken out in a comparable manner. The castings so produced were inspected for surface smooth-

TABLE 3 — GREEN MOLD MIXTURES FOR VARIOUS METALS

	Gray Iron		Bronze		Aluminum	
Mix No.	1	2	3	4	5	6
New Jersey 60 Silica sand, Lb	1440	—	—	—	—	—
New Jersey 120-2 Silica sand, Lb	—	—	105	—	—	—
New Jersey 160 Silica sand, Lb	—	—	—	—	1000	—
Providence River sand, Lb	—	—	105	—	—	—
Fluid coke, Lb	—	30	—	40	—	40
Cereal, Wt. %	1.2	1.2	—	—	—	—
Wheat flour, Wt. %	1.0	—	—	—	—	—
Western bentonite, Wt. %	2.0	4.0	—	—	—	—
Southern bentonite, Wt. %	5.8	—	4.8	5.1	4.0	4.1
Wood flour, Wt. %	—	—	—	—	0.4	0.4
Sea coal, Wt. %	4.4	—	—	—	—	—
Pitch, Wt. %	—	—	1.0	1.0	—	—
Moisture (determined) Wt. %	3.6	4.8	3.3	3.8	6.0	4.9
Lytron, Wt. %	—	—	—	—	0.025	0.025
Physical Properties						
Green permeability	81	49	52	37	27	34
Green compression, p.s.i.	6.3	5.4	8.2	4.7	4.4	3.4
Green deformation, in./in.	0.012	0.028	0.012	0.012	0.019	0.020
Hot strength, 1500 F, p.s.i.	95	165	180	180	442	101
Hot strength, 2000 F, p.s.i.	16	4	102	6	55	3
Thermal expansion, 1500 F, in./in.	0.028	0.004	Not Run	Not Run	0.015	0.006
Metal specifications	A.S.T.M. A48	Class 45	Navy M Bronze		Heat treatable Si-Al alloy	
Metal pouring temperature, F	2620	2620	2250	2250	1290	1290

NOTE: Mixes 1, 3 and 5 were regular production batches.

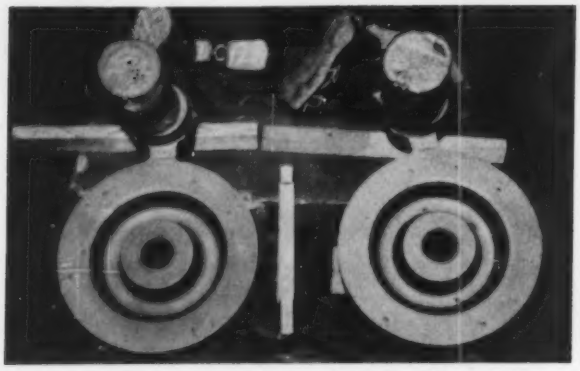

Fig. 1 — Gray iron castings made in fluid coke green mold (left) and green sand mold (right).

ness, chill tendency, sulfur and carbon pickup, shrinkage tendency and grain structure.

It was established by observation that better peel was obtained with fluid coke than with regular molding sand, the castings taken from the fluid coke molds being clean and practically free of any adhering mold material. All the castings, gray iron, (Fig. 1) bronze and aluminum, cast in fluid coke molds showed somewhat smoother surface finish than respective castings produced in the regular sand molds. Brinell hardness readings (not recorded) established there was no appreciable difference in hardness between castings made in fluid coke and those made in sand. Radiographs taken of the gray iron castings showed some improvement in internal soundness of the castings produced in fluid coke molds.

Of particular significance, photomicrographs of etched cross-sections of the bronze and aluminum castings revealed a finer grain structure was obtained with both bronze and aluminum cast in fluid coke molds than was obtained in the sand-cast castings (Fig. 12).

Tests of Fluid Coke in Baked Cores

To determine the characteristics of fluid coke as a replacement for zircon and silica sands in baked cores, a mold and core assembly was utilized in a fashion to accommodate six 2 in. diameter standard permeability based core specimens prepared from the core mixtures given in Table 4. Thus, fluid coke was compared to zircon sand, silica sand and their mixture, as indicated in Table 4 (Figure 2 is a drawing of the test mold, similar designs of which are familiar to most foundry researchers. Figure 3 illustrates the mold and test cores prior to closing). Navy *M* bronze was poured at 2075 F (1079 C), and the resultant casting (Fig. 4) was inspected for any differences in the cored area.

For the purpose of discussing the results observed, the core location numbers also identify the composition of the cores as given in Table 4. The cored areas of the test casting (Fig. 4) at locations 1, 2, 3 and 5 showed no penetration. Considerable veining was present at location 6, and location 4 was completely penetrated. The conclusion drawn was that fluid coke was equal to zircon sand and much supe-

TABLE 4 — CORE MIXTURES FOR PENETRATION TEST WITH NAVY M BRONZE

Core Location in Test Casting	1	2	3	4	5	6
Fluid coke, Lb	25	25	12.5	—	—	—
Zircon sand, Lb	—	—	12.5	1020	50	—
New Jersey 60 Silica sand, Lb	—	—	—	930	—	1440
Cereal, Wt. %	2.0	2.0	2.0	0.4	—	0.5
Highly dextrinized cereal, Wt. %	—	—	—	0.1	0.1	0.2
Southern bentonite, Wt. %	—	—	—	—	0.5	—
Core oil A, Wt. %	2.0	—	2.0	—	—	—
Core oil B, Wt. %	—	2.5	—	0.7	1.5	0.8
Moisture (determined) Wt. %	6.6	6.0	6.0	5.5	1.4	5.8
Physical Properties						
Dry permeability No.	27	27	21	65	37	140
Scratch hardness	91	87	100	97	88	88

Test cores.....2 in. diameter standard permeability specimen.
Baking equipment....Air-circulating laboratory oven.
Baking temperature...425 F.
Baking time.....2 hr
Wash treatment.....All baked specimens coated with 40 Baume graphite wash.
Weight of test casting..178 lb (including riser)

NOTE: Mixtures 4 and 6 were regular production batches. All other mixtures were mixed in a laboratory mixer — 3 min dry, 3 min water, 5 min oil.

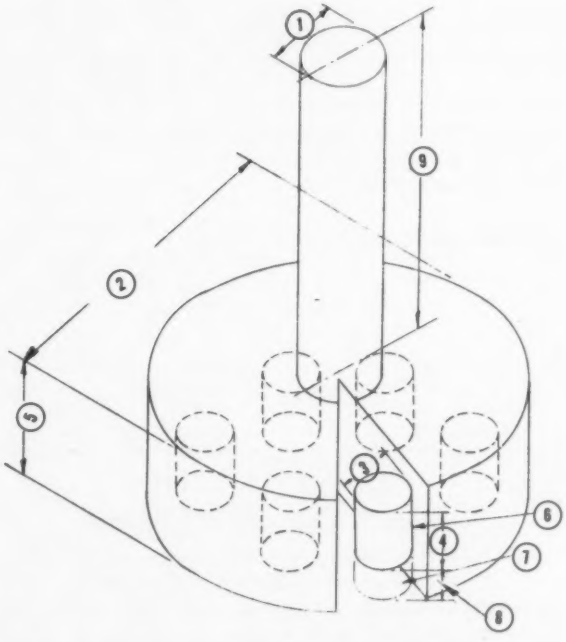

Fig. 2 — Drawing of mold and core assembly used to show comparative penetration of bronze into baked test cores. Weight of casting and riser — 178 lb. *1* — 3 dia; *2* — 13 dia; *3* — 2 dia; *4* — 2 in.; *5* — 4 in.; *6* — core 2 in. dia, 3 in. long; *7* — core print one in. deep; *8* — one in.; *9* — 11 in.

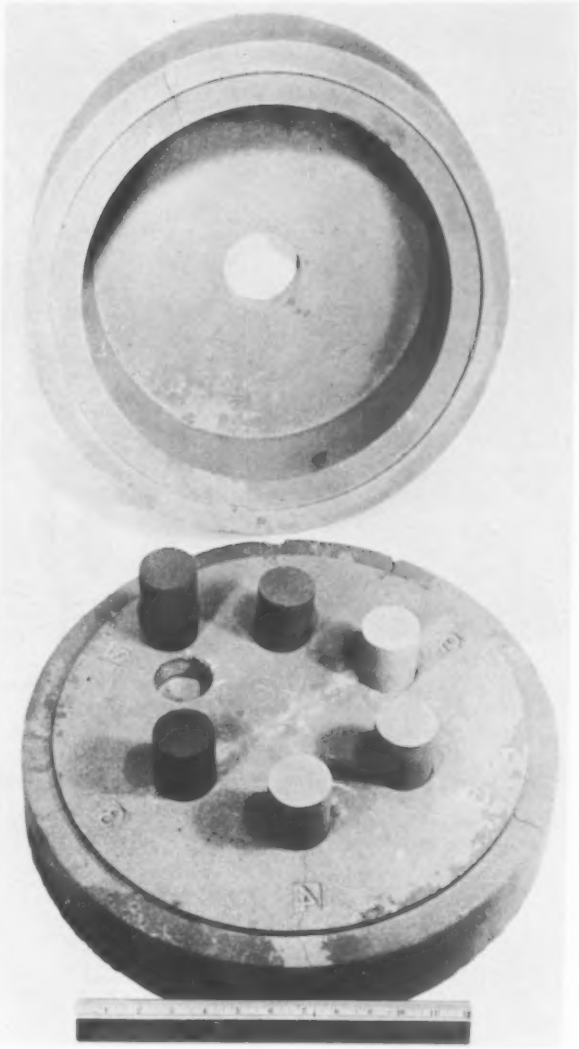

Fig. 3 — Penetration test mold showing location of test cores.

rior to silica sand in resistance to penetration of Navy *M* bronze under the conditions of this test.

To further compare fluid coke to zircon sand as a coremaking material, centrifucal pump impeller cores were prepared from each according to the core mixtures and data given in Table 5. The test cores were baked, coated with 40 degrees Baume commercial graphite base core wash, set in the molds and poured with Navy *M* bronze. The resultant castings (Fig. 5) were examined for condition of the cored areas. Both castings were smooth and free of veining in the cored areas. It can be said that fluid coke proved equal to zircon sand under the conditions of this test.

To evaluate fluid coke as a coremaking material for use with gray iron, cores were made for commercial gray iron bearing housings, according to the core mixtures and preparation data shown in Table 6, thus comparing a fluid coke core with the silica sand core regularly used for these castings. The molds for these castings were baked molds of the same composition as the respective cores. These molds were poured consecutively with gray iron at 2480 F (1360 C). Castings were radiographed, then cross-sectioned for examination (the cored areas are shown in Figs. 6 and 7).

The radiographs revealed two small areas of shrinkage porosity in the casting produced with the sand mold and cores, whereas, only one small area of shrinkage porosity was evident in the casting made with the fluid coke mold and cores. The surface finish on both mold and core areas of the casting made with fluid coke was superior to that obtained with the sand mold and cores.

Test of Fluid Coke for Shell Molds

To investigate the use of fluid coke as a replacement for silica sand in shell molds, a mixture of fluid coke and 6 Wt. per cent powdered shell mold resin was prepared in the same fashion as a mixture of No. 155 Superior Dividing Creek sand and 6 Wt. per cent of the same resin. Shell molds for aluminum air hammer housings were made with each mixture. The shells were invested on heated patterns by the dump box method and cured under electrical resistance heaters. Regular oil sand cores were set in

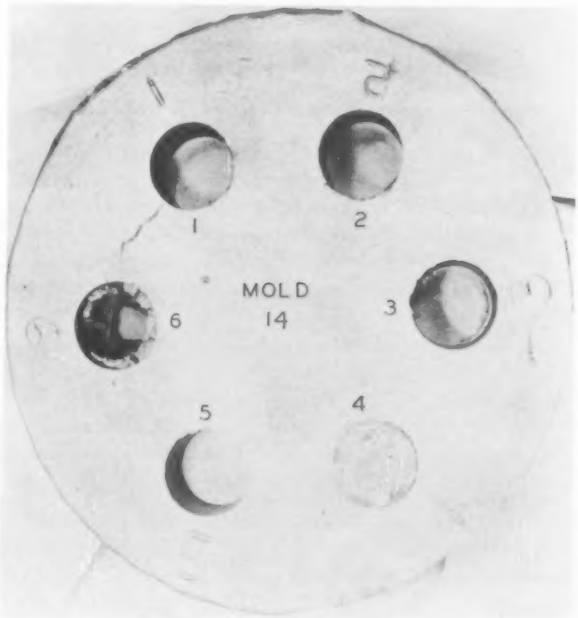

Fig. 4 — Penetration test bronze casting showing degree of penetration into each test core (location numbers identify core composition as given in Table 4).

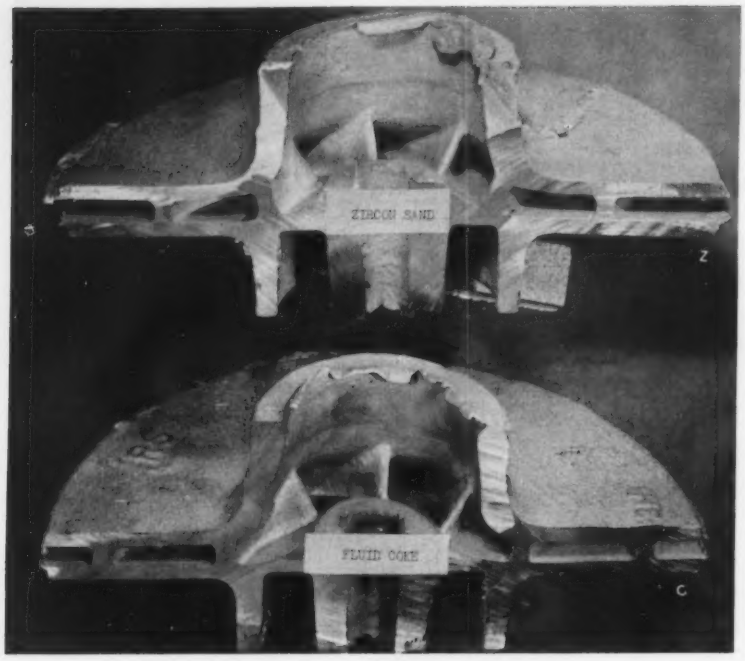

Fig. 5 — Cross-sections of bronze pump impellers showing interiors cored with zircon sand core (top) and with fluid coke core (bottom).

TABLE 5 — CORE MIXTURES — FLUID COKE VS. ZIRCON SAND FOR NAVY M BRONZE PUMP IMPELLERS

Mix no.	1	2
Zircon sand, (AFS no. 95) Lb	500	—
Fluid coke, (AFS no. 95) Lb	—	25
Core oil, Wt. %	0.5	2.0
Cereal, Wt. %	—	2.0
Moisture, Wt. %	0.8	7.0
Physical Properties		
Dry permeability	39	39
Scratch hardness	98	100

Baking equipment .....Production Batch-type Oven.
Baking temperature....400 F.
Baking time.....3½-hr.

NOTES: 1. The fluid coke was sieved and blended to match the AFS Fineness number of the zircon sand.

2. Mix 1 was regular batch from foundry core room. Mix 2 was mixed in a laboratory mixer — 3 min dry, 3 min water, 5 min oil.

these molds. The molds were clamped and poured horizontally with heat treatable silicon-aluminum alloy at a pouring temperature of approximately 1290 F (699 C). The aluminum castings so produced were compared for surface finish and soundness (castings and molds are shown in Fig. 8).

The casting produced in the fluid coke shell mold was of somewhat smoother surface finish then the casting made in the silica sand shell mold. Photomicrographs (Fig. 13) taken on the cross-sections of both aluminum castings showed a finer grain structure was obtained with the fluid coke shell mold.

Test of Pulverized Fluid Coke in Core Wash

Fluid coke was pulverized to a particle size of 96 per cent through U.S. 200 mesh for use in a test to determine its characteristics as the principal ingredient of core wash. A fluid coke core wash having a 39 degrees Baume gravity was prepared according to the formula:

Material	Wt. %
Fluid coke (200 mesh)	42
Western bentonite	3
Dextrin	2
Water	53

A test was set up to compare this wash with a commercial graphite base core wash having a gravity of 40 degree Baume. Two identically baked oil-sand cores were dipped, one core being coated with fluid coke and the other with commercial graphite wash. Both cores were dried in a production drying oven and then placed in a double casting mold to produce, in a single mold, a gray iron casting with each core (Fig. 9). Gray iron was poured at 2600 F (1427 C). The castings were cross-sectioned and examined for surface finish on the cored areas (Fig. 10). The casting produced with the core coated with the fluid coke core wash showed somewhat smoother surface finish than was obtained with the commercial graphite base core wash.

FURTHER OBSERVATIONS AND DISCUSSION

The first trail of fluid coke as a molding medium established one basic characteristic subject to earlier apprehension. It was immediately determined that fluid coke would not ignite and be consumed by the heat of the molten metal. Fluid coke grains in direct contact with molten iron may burn to a white ash, however, the grains immediately adjacent to this ash

appear to remain unaffected. The amount of ash formed is not sufficient to prevent continuous recycling of shakeout fluid coke.

Fluid coke, used either as mold and core material or as a wash is considered beneficial for peel, since castings shake out clean and practically free of any adhering mold and core material. Furthermore, fluid coke assures a reducing or inert blanket of gas at the mold-metal interface during pouring, without addition of sea coal or other organic materials ordinarily used for that purpose. In no case, during the many tests, did any casting show a blow or other defect due to gas evolution from fluid coke.

Bulk Density. The low bulk density of fluid coke as compared to sand requires special consideration. As shown in Table 1, the fluid coke used in these tests weighed 9.26 lb/gallon, whereas most foundry sands weigh near to 12 lb/gallon. Since practically all additives and binders function on a volume relationship to the base material, it follows that a larger weight percentage of water and binders is generally needed to produce fluid coke mixtures having green and baked strengths equivalent to sand mixtures. While this bulk density ratio of fluid coke to sand was not generally followed in setting up the fluid coke mixtures described in this paper, it should be kept in mind in interpreting the physical properties of the mixtures used.

From a material handling standpoint, the fluid coke used in these tests weighed approximately three-fourths the weight of an equal volume of silica sand, and less than 40 per cent the weight of an equal volume of zircon sand.

Thermal Expansion. The low thermal expansion of fluid coke as compared to silica sand is, perhaps, its most unique characteristic. In all thermal expansion tests, which have been run on fluid coke mixtures, using the $1\frac{1}{8} \times 2$ in. specimen in a dilatometer at 1500 F (816 C), the highest expansion value was 0.006 in./in. and the lowest was 0.002 in./in. In most cases, thermal expansion of fluid coke mixtures was about one-seventh that of a corresponding silica sand mixture.

TABLE 6 — CORE MIXTURES FOR GRAY IRON TEST CASTING

Mix no.	1	2
New Jersey 60 silica sand, Lb	1440	—
Fluid coke, Lb	—	40
Corn flour 1, Wt. %	0.5	2.0
Corn flour 2, Wt. %	0.2	—
Core oil, Wt. %	0.83	2.0
Moisture (determined), Wt. %	6.8	7.0

Baking equipment ..... Production Vertical Oven.
Baking temperature ..... 550 F.
Baking time ..... 1¾-hr, load to unload.
Wash treatment ..... Both baked cores coated with 40 Baume graphite wash.

NOTE: Mix 1 was regular production batch from foundry core room.

Mix 2 was mixed in a laboratory mixer — 3 min dry, 3 min water, 3 min oil.

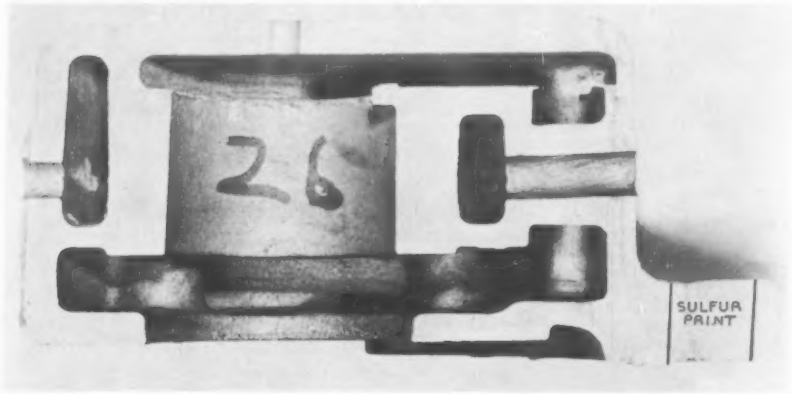

Fig. 6 — Cross-section showing cored area of gray iron casting produced with baked oil-bonded fluid coke mold and cores.

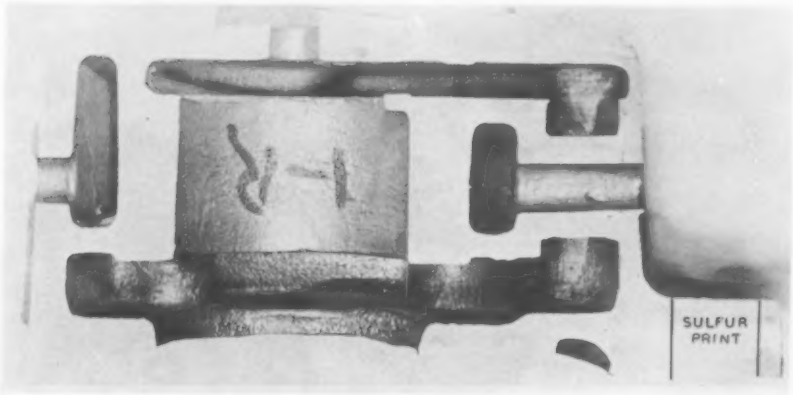

Fig. 7 — Cross-section showing cored area of gray iron casting produced with baked oil-bonded silica sand mold and cores.

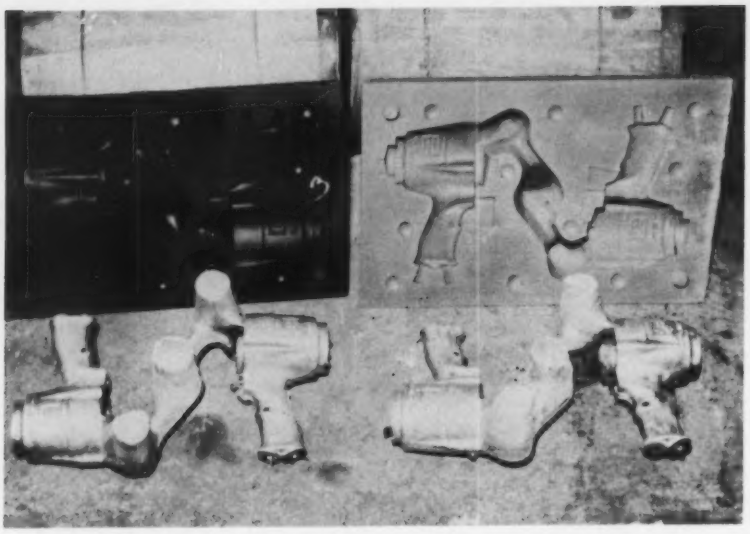

Fig. 8 — Aluminum air hammer housings cast respectively in fluid coke shell mold (left) and silica sand shell mold (right).

Fig. 9 — Gray iron castings cored with oil-sand cores coated with fluid coke core wash (right) and commercial graphite-base core wash (left).

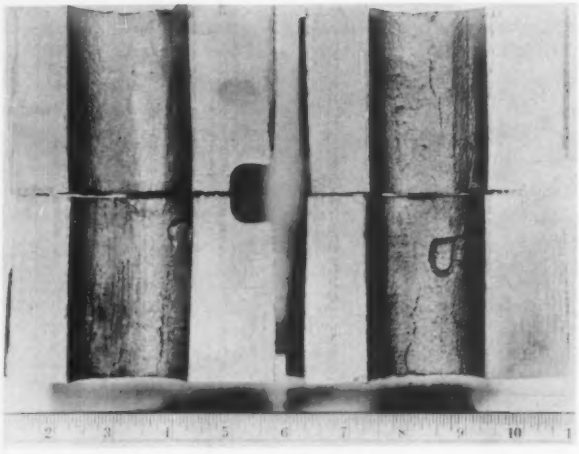

Fig. 10 — Cross-sections of gray iron castings showing areas cored with fluid coke core wash (left) and commercial graphite-base core wash (right).

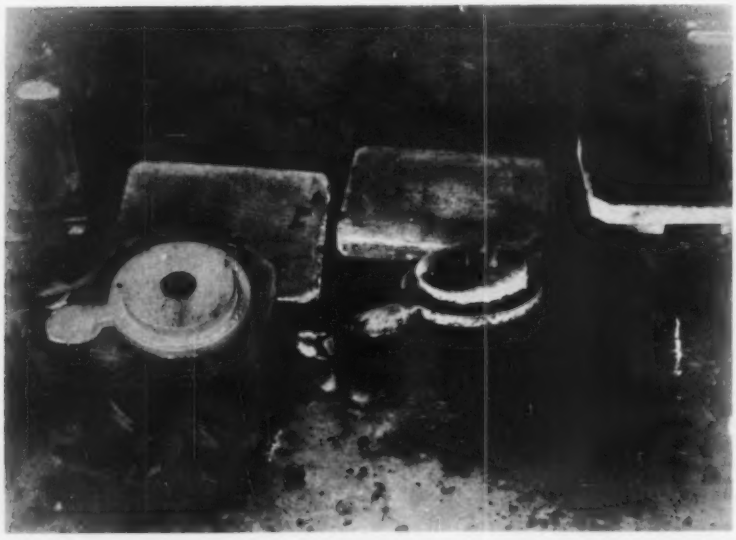

Fig. 11 — Gray iron castings shaken out 30 min after pouring showing faster cooling with fluid coke green mold (left) compared to green sand mold (right).

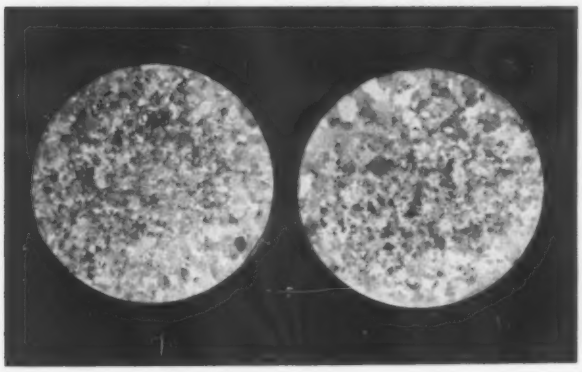

Fig. 12 — Photomicrographs showing grain structure of bronze cast in green mold of fluid coke (left), and sand mold (right).

Fig. 13 — Photomicrographs showing grain structure of aluminum cast in shell molds of fluid coke (left) and silica sand (right).

Thermal Conductivity. As could be expected, fluid coke conducts heat rather rapidly. Core baking time and investment and cure times for shell molds can be shortened somewhat.

The effect of heat transfer on the progressive solidification and cooling rate of castings poured in fluid coke is a more important consideration. Identical gray iron castings shaken out 30 min after pouring showed the casting poured in a sand mold to be a cherry red heat, while the casting made in a fluid coke mold was at black heat (Fig. 11). Contrary to expectations, no chilling effect was evident on the casting surface. Due to the faster cooling of the castings made in fluid coke, there was some evidence of less shrinkage within the castings, which would indicate that fewer or smaller risers would suffice to feed the casting, and in some cases, risers might be eliminated. Less shrinkage in the casting is believed attributable to both the faster cooling of the castings and to the thermal stability of the fluid coke molds.

Photomicrographs revealed that a finer and tighter grain structure was obtained in bronze and aluminum castings made in fluid coke. The advantages realized in strength and pressure tightness are obvious. This improved grain structure is considered due to the faster cooling rate provided by fluid coke (Figs. 12 and 13).

Surface Finish. The most obvious advantage obtained with fluid coke was the superior surface finish of gray iron, bronze and aluminum castings produced with fluid coke green molds, baked cores, shell molds and core wash. Since molten iron does not wet carbon, and considering the low thermal expansion of fluid coke, a decrease should be expected in casting defects such as penetration, burn-on, veining, scabbing and rattailing through the use of fluid coke.

CONCLUSION

The advantages of fluid coke appear to be these:

1. The grain structure, grain size and grain distribution of fluid coke is similar to that of foundry sands, and therefore, it lends itself to handling with ordinary foundry equipment.
2. The high carbon content of fluid coke provides low thermal expansion and resistance to penetration by molten metal.
3. The high rate of heat conductivity with fluid coke provides faster cooling of castings before shakeout, with consequent improvement in soundness and grain structure of the castings, particularly bronze and aluminum.
4. Fluid coke imparts superior surface finish to castings by any casting method in which it has been so far tried.
5. The low weight per unit volume of fluid coke reduces the effort and cost of handling.

This preliminary evaluation of fluid coke as a molding medium covers some of the initial work done to determine its relative usefulness, as compared to more conventional materials. The tests indicated that, while fluid coke does not cure all foundry molding problems, it does merit consideration as an aid toward meeting the ever increasing demand for higher quality castings. Fluid coke is unique in that its most interesting characteristics serve to improve the resultant castings. Work has continued to determine the compatibility of fluid with the newer casting processes such as CO_2 process, cold-setting binder process, resin-coated shell mold practice and hot-box process. Suffice to say, the later work has further confirmed the reliability of the observations reported in this paper.

ACKNOWLEDGMENT

The author wishes to acknowledge and sincerely thank Ingersoll-Rand Co., Phillipsburg, N.J., for their cooperation and assistance in conducting the work described in this paper.

MAXIMIZING SOUNDNESS IN ALUMINUM DIE CASTINGS

by L. M. Elijah

ABSTRACT

The increasing usage of aluminum die castings, the insistent demands for higher mechanical requirements and the quickening tempo of production toward automation has made highest quality requirements mandatory. With this in view, a complete analysis is made of the known shortcomings, indicating causes and suggesting actual remedies which stress often overlooked and little known metallurgical features.

INTRODUCTION

With the rapid growth of aluminum die castings into a major industry, the headaches and pains which are part of the growth process have correspondingly increased. The fact that quality cannot be inspected into a part but must be cast into it, makes it vital that all precautions be taken before the molten metal is frozen in the die cavity. Procedures must be rigorously controlled and checked for discrepancies. Correct casting and die cavity design have been clearly indicated,[1] hence for the purpose of this paper, it will be generally assumed that they are followed. Other investigators have elucidated the theoretical and practical aspects of die casting thermo- and hydro-dynamics.[2,3,4] However, little has been mentioned as to the metallurgical factors involved.

MODE OF ANALYSIS

It should be recognized that the sources of defects are:

a. The die.
b. The machine.
c. The metal.

This can be further subdivided:

a. 1. Die cavity design.
   2. Operating conditions of the die.
b. Operational techniques of the casting equipment.
c. 1. The intrinsic nature of the alloy itself.
   2. Exact conditions for melting and pouring the alloy.

However, since most defects originate from two or more of the above factors, they will be generally classified as:

A. Observed prior to injection.
B. Caused during injection.
C. Observed subsequent to injection.

TROUBLE SHOOTING THE PROBLEMS

DEFECTS OBSERVED PRIOR TO INJECTION

Table 1 — Corrosion Resistance (Poor)

Classification:

Rapid surface deterioration (caused by oxidation, etc.) which mars the bright, shiny appearance.

Causes:

1. Improper surrounding atmospheres.
2. Exposure to the elements (storage outdoors).
3. Absence of grain refiners.
4. Alloy not suitable for particular application.

Corrections:

1. Presence of chlorine and hot furnace gases in atmosphere, hence store away from such fumes.
2. Store in dry, enclosed area.
3. Grain refiners like Ti help improve surface appearance.
4. Effects of elements are:

   Increasing amounts of Mg do not decrease the excellent corrosion resistance of Al. Si additions up to 13 per cent result in a slight deterioration (negligible for practical purposes). Up to 2.5 per cent Zn has no harmful effect. Increasing Cu content lowers corrosion resistance specially up to one per cent. Over this amount the alloy improves (hence Cu should be maintained below 0.3 per cent. Increasing Fe (over 0.5 per cent) generally lowers this property.

Table 2 — Drossing (High)

Classification:

Formation of excessive surface layer of impurities on molten metal.

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(Table 2 — continued)

Cause:

Oxidized metal (Al_2O_3) combined with spent flux, together with other impurities (usually nonmetallic). Al_2O_3 occurs eventually in castings either as smaller, well dispersed particles (seen unetched, under a low power microscope as tiny, dark specks on a polished surface) or as large, conglomerated masses (appearing as black spots under a low power microscope). The former is caused by insufficient cleaning of returned scrap or turbulent gating design. The latter is caused by careless ladling or neglectful metal cleaning and housekeeping operations.

Corrections:

1. Prevent undue turbulence under solid fluxing. For this reason, N_2 or Cl_2 gas bubbled quietly is more efficient (Cl_2 is better, but in alloys requiring Mg, loss of Mg must be compensated by having a slight initial excess).
2. In the cold chamber process, keep the surface clean. Ensure that the operator does not agitate the surface in order to obtain clean metal.
3. When transferring molten metal from one furnace to another or from a furnace to the injection chamber, pour in a thick, steady stream with a minimum of metal drop.
4. Oxidized, finely divided or coated scrap causes high dross. Make sure that the returns as well as fresh charge are bulky, clean and free from oxides, oil, dirt, paint, etc. Do not store metal outdoors or in contact with chlorine or furnace fumes.
5. Prevent overheating of the molten metal.
6. High magnesium content in an alloy causes excessive drossing. This can be reduced considerably by adding 0.01 per cent of each Be and Li. If possible, use an alloy low in Mg.
7. If a high magnesium alloy is required, make controlled use of Be.

Table 3 — Fluidity (Poor)

Classification:

Inadequate flowability of the molten alloy to fill intricate designs and sharp corners.

Causes:

1. Presence of sludge.
2. Presence of Al_2O_3 in metal.
3. Incorrect alloy composition.
4. Low temperatures decrease fluidity.
5. Alloy used has high shrinkage.
6. Inadequate feeding.

Corrections:

1. Eliminate conditions causing sludging.
2. Chlorinate metal to reduce Al_2O_3 inclusions and hence increase flowability.
3. Higher silicon content (up to 12 per cent) increases fluidity. High Mg causes drossing which reduces fluidity. Mn over 0.30 per cent reduces castability.

(Table 3 — continued)

4. Higher temperatures increase fluidity, enabling thin intricate sections to be poured.
5. If after using chlorine, poor fluidity still persists, add approximately 0.15 per cent Ti which tends to reduce shrinkage. Higher Fe content, up to one per cent, also reduces the shrinkage characteristics.
6. Increase ingate and feeding system.
7. The fluidity of alloy increases with an increase of Cu up to 12 per cent.

Table 4 — Hot Shortness

Classification:

At higher temperatures, alloys possessing this defect tend to embrittle.

Cause:

Basic characteristic of some alloys.

Corrections:

1. Presence of Sn, Pb increases hot shortness. Higher Mg alloys also have this tendency. Both Si and Ni tend to decrease this characteristic slightly. The tendency increases up to 4.5 per cent Cu and then decreases, this is reduced in the presence of one per cent Fe.
2. For design defects, refer to "Shrinkage Cracks."

Table 5 — Metal Loss (High)

Classification:

Low metal recovery on melting.

Cause:

Oxidation, sludging and carry out of metal during melting and pouring.

Corrections:

1. As any of the conditions that tend to cause excessive dross also causes high metal loss, observe the factors mentioned therein.
2. Similarly, all of the factors minimizing sludging (refer) must be followed.
3. In magnesium bearing alloys, maintain chlorination at a minimum as, along with the removal of magnesium, eventually aluminum is also removed.
4. The use of solid fluxes causes a carry out of molten metal when residues of the former are removed. Hence, during melting, casting and pouring, reduce the use of solid fluxes and dross removal to a minimum.
5. Employ indirect heating (e.g., electric induction and crucible type furnaces) in preference to direct-fired reverberatory furnaces.

Table 6 — Porosity — Gas Absorption

Classification:

Smooth round highly reflective holes, mostly internal and evenly distributed, caused by gas dissolved in the molten metal due to exposure to humid atmospheres, furnace combustion gases, wet or dirty charge, etc., and the eventual release of these gases on cooling and solidification. They decrease mechanical properties and if they appear at or near the surface, cause galling and seizing of tight contacting surfaces in motion.

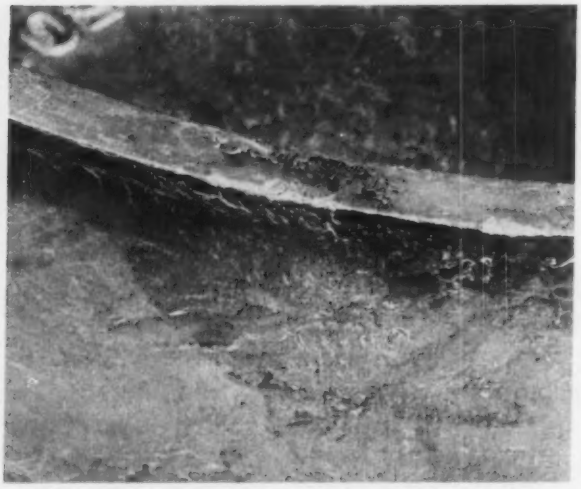

Fig. 1 — Porosity which could be caused by absorbed gas, turbulence or excessive die coating.

Cause:

Improper treatment of the molten alloy.

Corrections:

1. Use clean, dry scrap.
2. Melt rapidly. Do not overheat.
3. Degas thoroughly immediately prior to pouring (Cl_2 gas is most effective, however it also reduces Mg. Should be used in alloys where Mg is an impurity. In alloys containing Mg use N_2 gas).
4. Make sure that solid fluxes employed are thoroughly dry. If exposed to humid atmospheres, they tend to absorb moisture.
5. Ascertain that only dry gases are employed for degassing, e.g., dry, oil pumped N_2, etc.
6. Furnace design should be such that spent gases do not come in contact with the molten metal surface.
7. Make sure that excessive Ca is not present in the metal, as this tends to cause porosity. Ca can be minimized by fluxing with Cl.
8. Avoid violent stirring when adding solid flux to molten metal.
9. Possibly the die coating is excessive or defective. Check if oils, greases are the cause.
10. Vacuum melted castings will improve quality only if molten metal is initially degassed.
11. Use may be made of high frequency vibrations before solidification to minimize porosity.

Table 7 — Sludging (High)

Classification:

Segregation of various constituents of the alloy.

Cause:

Precipitation of higher melting point intermetallic compounds generally caused by a lowering of temperature, presumed to be nucleated by formation of $MnAl_3$ at cold spots. The presence of Al_2O_3 particles (finely divided or chunk) in the melt also act as nuclei to accelerate precipitation.

Corrections:

1. Preheat metal charge being added (to approximately 600 F (316 C) away from open flame). Add gradually to prevent localized or general chilling of the melt.
2. Raise the temperature of the melt to approximately 350 F (177 C) above the liquidus, and mix gently to bring all of the more refractory constituents into solution at regular intervals. Use dry N_2 for degassing and mild mixing. Cl_2 gas is preferable as it also cleanses the melt of Al_2O_3, however its effect on Mg must be considered. Maintain an operating temperature of at least 70 F above liquidus in the electric and 100 F in the crucible type furnaces.
3. Use an electric induction furnace in preference to gas or oil fired furnaces, owing to the constant automatic metal circulation.
4. If sludge formation is excessive, empty the furnace completely before introducing a new heat, because after most of a heat is used and it is then corrected by a high temperature reheat, as in step 2, the composition of the contained liquid would go out of tolerance as also the metal used.
5. Keep Mn as much below 0.30 per cent as possible. Also use alloys in which Cr, Ti and Fe are as low as possible. At normal pouring temperatures, just above the liquidus, if the total of ($\%$ Fe + 2 × $\%$ Ti + 2 × $\%$ Mn + 3 × $\%$ Cr) exceeds 1.9, sludge will form. 356 (7.5 per cent Si and 0.85 per cent Fe) has less tendency to dross, oxidize or sludge than 360 or 380. 43 forms a crust and clogs channels of induction furnace at 1200 F (649 C). This may be corrected by maintaining at 1225 F (657 C) but it reduces production by 25 per cent due to higher freezing time. By changing to an alloy with 9.0 per cent Si, crust disappears at 1200 F (649 C).
6. a) If an iron crucible is used, coat it internally at frequent, regular intervals.
   b) The burners should not heat the contents unevenly, causing hot and cold spots.
7. It is preferable to have separate melting and holding furnaces, so that there is no chilling effect of a continuously added cold charge and the correct composition of metal is maintained.
8. If separate melting and holding furnaces are not available, after addition of each batch of fresh ingots or a cold charge, the whole contents must be reheated as in step 2.
9. Do not add more metal than that which the furnace burners can handle effectively.

(Table 7 — continued)

10. Sometimes excessive amounts of an element like Ni increases general liquidification temperatures, causing a premature freezing at a given operating range.

Table 8 — Venting of Dies (Poor)

Classification:

This defect causes misruns, laps, seams, etc.

Cause:

Back pressure of air in the die-mold which prevents complete filling of the cavity.

Corrections:

1. For the efficient working of a hot dry die, vents should be at least half the gate area.
2. With increased lubrication and colder dies, the venting area should be increased.
3. It is advisable to vent from the overflow cavities.
4. Ensure that the metal does not plug the venting orifices prematurely.

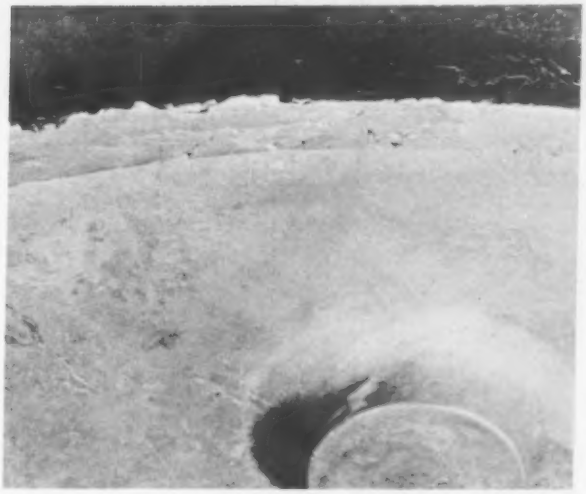

Fig. 2 — Folds observed in the metal as a result of cold die or metal, excessive die coating or inadequate venting.

5. Use die release spray that dissipates below operating die temperatures to give least back pressure. If dies operate at 350 F, the die release spray should evaporate below this temperature.

CASTING DEFECTS

Table 9 — Cavities — Reciprocating Plunger Action

Classification:

Ragged cavities occurring both internally and externally at various locations. They sometimes appear as approximately parallel surface cracks.

Cause:

When a plunger is at the bottom of its stroke, should the injected metal not be completely solidified and the plunger not allowed to dwell long enough in this position, by its quick withdrawal, it will suck back on the mushy, semi-liquid metal in the mold, causing this defect.

Corrections:

1. Hold the plunger at the bottom of its stroke a fraction longer.
2. Decrease the gate section so that the metal chills off before the sucking action of the plunger can deform it.
3. Water cool ¾ - 1¼-in. below the die cavity to expedite solidification.
4. Prevent overheating of the molten metal and die.

Table 10 — Cavities — Shrinkage

Classification:

Ragged, irregularly shaped cavities caused by internal shrinkage. They possess dull cavities as opposed to gas entrapment or porosity which are rounded and highly reflective.

(Table 10 — continued)

Cause:

Inadequate feeding of shrinkage in a casting because of the premature bottleneck freezing action of the molten metal nearer to the gate or the adjacency of a thin and thick section (shrinkage resulting from a difference in specific volumes of the molten metal at the liquidus and the solidified metal at its solidus temperature).

Corrections:

1. Check if die temperatures are too low.
2. Even out die temperatures, by increased feeding, using thicker gates and more overflow wells adjacent to the coolest portion.
3. Minimize drastic changes in section thickness.
4. Increase injection pressure.
5. Use a grain refiner for the molten metal (refiners are not normally necessary due to the chill of the metal die, however presence of 0.15-0.20 residual Ti in the melt sometimes helps to decrease defect. Use should be made of a 5 per cent Ti, 95 per cent Al master alloy).
6. Use an alloy with better feedability characteristics.
7. Check if lower metal temperatures would decrease this defect without causing cold shut.

Table 11 — Cold Shut

Classification:

Marks caused by metal streams failing to merge together and completely fill the die cavity. Linear in appearance, they are noted by the absence of non-

(Table 11 — continued)

metallic materials (if they look like flakes of unmelted metal, it is due to metal folds containing die lubricant caused by turbulence because of too large a gate and excessive lubricant).

Fig. 3 — Depressed edge caused by incomplete filling.

Causes:

Advancing metal front divides into two streams which lose heat, develop thin oxide surface films (possibly also contain oxidized metal) and upon meeting, fail to interdiffuse partially or completely into one another, because of sluggishness, insufficient velocity or pressure to break the oxide film surface tension or due to the back pressure of air or gas, in the cavity.

Corrections:

1. If the die is cold, increase the temperature.
2. Check if the cooling channels are approximately 1 to 2 in. from the die cavity.
3. If poured metal is cold, increase temperature but do not heat excessively.
4. Reduce mold back pressure by adequately venting the cavity.
5. Increase injection pressure to help complete the merging of metal surface fronts.
6. If high plunger speeds tend to trap air, check if a lower speed would reduce this defect.
7. Adjust runner and ingate size (increase if too small). Correct other design deficiencies.
8. Improve fluidity of the alloy by minimizing oxide formation through adequate fluxing, prevention of overheating, eliminating turbulence during melting and pouring, controlling other impurities which would cause sluggishness.
9. Employ another alloy with better fluidity as a last resort.
10. As may be evident, most of the above factors can be minimized by vacuum die casting.

Table 12 — Cracks — Shrinkage

Classification:

Cracks caused by shrinkage upon cooling.

(Table 12 — continued)

Cause:

Internal shrinkage stresses exceeding the mechanical properties of the alloy.

Corrections:

1. If the metal solidifies around a core, increase the taper or remove the casting promptly off the core, or employ an alloy that is not hot short (refer).
2. Even out drastic changes to improve casting design in section and eliminating stressed areas.
3. Check if the designated alloy has adequate mechanical properties (refer).
4. If lower mechanical properties are obtained due to low injection pressures, chemical composition of the alloy or other reasons listed in Table 26, follow the recommendations listed therein.

Table 13 — Depressions — Shrinkage

Classification:

Shrinkage depressions on the surface of casting which are caused by inadequate feeding, slow cooling or heavy section, usually appearing as dished, depressed areas.

Causes:

1. Pure Al, higher Zn alloys, alloys containing over 5 per cent Ni or below 0.5 per cent Fe, etc., having a high shrinkage, accentuate this problem, sometimes resulting in cracks or cavities at the vertex of inside corners and changes of sections.
2. Inadequate feeding, e.g., low injection pressures or small injection ingates.
3. Heavy section adjacent to a thin section.
4. At areas of slow cooling, hot spots, where the casting is fed by too small an ingate, or where the metal impinges against a core.

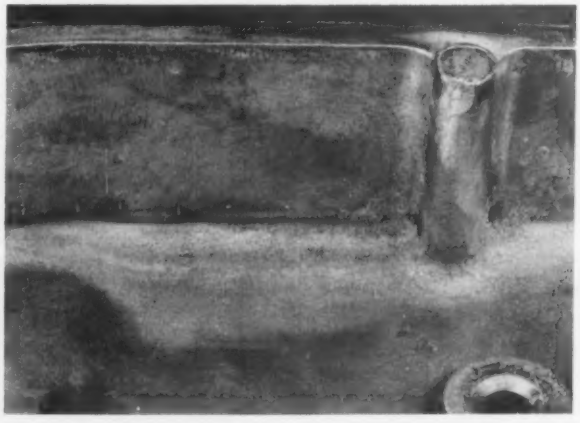

Fig. 4 — Frosted appearance and shrinkage depressions at the corners due to hot spot caused by ingate.

Corrections:

1. Use alloy with higher Fe content (0.9-1.3 per cent) and Mn up to 0.30 per cent.

(Table 13 — continued)

2. Feed correctly.
3. Even out section thicknesses.
4. Eliminate causes of hot spots.

Table 14 — Flow Lines

Classification:

Marks confined to the surface having no appreciable influence on the strength of the casting. Difficult to remove for plating.

Causes:

1. Excess of die lubricant (entrapped die lubricant areas appear black at low magnifications and highly reflective at higher magnifications).
2. Improper gate location.
3. Back pressure in the die cavity.

Fig. 5—Flow lines near ingate.

Corrections:

1. Excess of lubricants or dressings (especially in the hot sleeve) can cause this defect. Eliminate any excess lubricant, enlarge die vents and incorporate more overflow pads.
2. Ensure adequate venting.
3. Increase injection pressure.
4. If the die temperature is low, increase gradually and observe effect (if die is too hot, increased gases will cause worse flow marks).
5. Increase runner channels or enlarge gate entry.
6. Vacuum die casting can be useful.

Table 15 — Leakers (Poor Pressure Tightness)

Classification:

Leakages obtained under pressures which the given wall thickness is normally expected to withstand.

Causes:

Shrinkage, oxide inclusions, cold shut, laps, misruns and porosity caused by improper melting procedure, can result in this defect.

Corrections:

1. If possible, modify the die design to minimize shrinkage. This usually occurs in the same location, being caused by hot spots, inadequate feeding, etc. Also follow the recommendations outlined previously.
2. Decrease shrinkage by employing more suitable alloy, e.g., pure Al has a high shrinkage value (6.3 per cent), on the other hand alloy 13 has low shrinkage (3.3 per cent), yet because both have a narrow freezing range, cavities will be observed.
3. Minimize the occurrence of Al_2O_3 inclusions by not overheating the molten metal and fluxing thoroughly. These oxide inclusions are of two types, skin or chunk, both vary in density of population and location. It is industrially impractical to allow the oxides to settle as considerable delay is involved.
4. Cold shuts, laps, misruns, etc., vary their location and are caused by low pouring temperatures and cold dies. Try to eliminate them.
5. Check porosity due to injection turbulence (refer) or gas absorption (refer), by making adequate provision for vents and overflow pads.

Table 16 — Porosity — Turbulence

Classification:

These holes are rounded in nature, being trapped air caused by the turbulence of the injection process. They show a high degree of reflection in the cavities (as opposed to shrinkages which have ragged edges and dull cavities). They decrease mechanical properties and if they appear at or near surface, they cause galling and seizing of tight contacting surfaces in motion.

Cause:

Agitation during injection and pouring.

Corrections:

1. Pour molten metal into the cold chamber as quietly and with as low a drop as possible.
2. Decrease plunger speed (to minimize squirting and churning) without reducing pressure.
3. Use more or larger overflow wells and increase venting to help lessen the effect to a limited extent.
4. Increase injection pressure.
5. Reduce sudden changes of direction and their frequency of occurrence to a minimum.

(Table 16 — continued)

6. Increase depth of ingates gradually. Check results at each stage. Excessively thick ingate causes porosity at break-off point.
7. Change the ingate position to relocate porosity in a less critical area (as a final resort, if it cannot be eliminated).

Table 17 — Seams

Classification:

Surface lines caused by the outer layers of two streams failing to interdiffuse completely.

Causes:

Even though the metal when poured may be hot enough to fuse, the extreme outer layers only of the two streams (chilled by the die) will not fuse when the two streams meet, causing fine seams. The depth increases at lower die temperatures. Sometimes hair cracks in the die, due to thermal attack, also impart this appearance.

Fig. 6 — Seam clearly visible at edge of hole.

Corrections:

1. Raise the die temperature (if cold).
2. Check if the die has hair cracks.
3. Check if the die cavity is adequately vented.
4. Increase injection pressure to help metal surfaces to merge.
5. Vacuum die casting can help this defect.

Table 18 — Soldering to Die

Classification:

Casting adhering to die mold resulting in pimples, torn skin on certain areas of the casting.

Cause:

Molten aluminum being almost a universal solvent,

(Table 18 — continued)

first removes the oxide skin, then tends to alloy with the hot unoxidized iron die surface that it impinges against.

Fig. 7 — Torn skin as a result of die soldering.

Corrections:

1. Avoid high metal temperatures.
2. Avoid high die temperatures.
3. Prevent metal impingement on the critical area of die cavity by slightly altering die design by:
   a) Increasing ingate area.
   b) Altering angle of impingement.
   c) Slowing down injection speed.
4. Polish critical area of the die cavity to a high finish, after modifying the metal impingement direction and velocity.
5. Check die coating.
6. Verify if the alloy composition is correct (0.8-1.2 per cent Fe reduces die soldering).
7. If metal has been chlorinated, remove dissolved Cl_2 gas, $AlCl_3$ or $MgCl_2$ by cleaning with N_2 gas before usage.
8. Allow impurities like $MgCl_2$ to rise to top as a crust and remove (if production is not slowed down).
9. Examine die cooling system to ascertain if the critical area is being adequately cooled.
10. Check if correct die steel is employed.
11. Sludge particles in the metal promote die soldering. Ensure that causes of sludge formation are eliminated.

Table 19 — Stickers (To Die)

Classification:

Castings that are either difficult to eject or stock to the wrong die half.

Causes:

Improper die design with regard to casting balance, ejection, taper, surface finish. Incorrect die coat.

Corrections:

1. Minimize surface roughness at the undesired "area of adhesion," e.g., normally the casting is retained on the sprue pin side, from where it is ejected. For this reason, the sprue hole should be well polished and the sprue plug relatively rough to retain the casting on the plug side from where it may be ejected.
2. Incorporate sufficient ejection pins, evenly and properly located.
3. Balance the castings evenly about the sprue (if possible).
4. Check if the die spray is effective.

Fig. 8 — Part of metal around hole scraped out due to contraction of metal around core.

5. Ensure that taper and draft requirements are adequate (per A.D.C.I. standards[1]).
6. Determine if inserts or cores hinder ejection.

DEFECTS OBSERVED SUBSEQUENT TO INJECTION

Table 20 — Anodizability (Poor)

Classification:

Poor surface appearance caused by nonuniform anodizability.

Causes:

Incorrect alloy, unclean surface, nonuniform basic surface characteristics such as variation in composition or condition of alloy constituents, streaks, stains, foliations, scratches, etc. Lubricant and oxide defects appear as dark clouded areas upon anodization. Where a surface has been buffed, it should be examined for oxides under low magnification as color dyeing after anodization accentuates this defect.

Corrections:

1. Pure Al has the best anodized appearance but is difficult to die cast. Alloys high in Si and Cu yield a poor appearance upon anodization. Use alloys low in Si (max. 0.75 per cent) and Cu (max. 2.5 per cent). Al-Mg alloys on the other hand do not produce a clear finish. Small variations in composition cause a change in coloring.
2. Inadequate cleaning of die coat, lubricant, fingerprints, etc., can cause a patchy surface. Ensure correct die lubrication during injection and thorough cleaning immediately prior to anodizing.
3. Eliminate any of the factors that could cause flow lines (refer).
4. Scratches probably marring the surface (refer).

(Table 20 — continued)

5. Check if staining is the basic cause (refer), or streaking (refer).
6. Determine if foliation is responsible (refer) or poor polishability (refer).
7. Inhomogenous treatment, improper production practice, e.g., nonuniform die temperature or heterogenities in the metal itself (to which a casting is more susceptible than sheet or extrusion, etc.) tend to show up on anodizing. A homogenizing anneal in the range of 900-1000 F (482-538C) for 24 hr, depending on the alloy, sometimes can be of benefit (if anodizability is more important than any other property).

Table 21 — Extruded Surface Defects

Classification:

Whiskers or mushroom shaped droplets on casting surface.

Causes:

Pressure in metal forcing the higher melting point liquid complex from the interior through the solidified surface dendrites due to:

1. Usage of certain types of alloys (e.g., 195 contains 4.5 per cent Cu, however, extruded droplets sometimes contain 30 per cent Cu).
2. Gas absorption by the molten metal.
3. Heavy section thickness.
4. Chilling of surface.
5. Premature removal of casting from die mold.

(Table 21 — continued)

Corrections:

1. Use standard recommended die casting alloys.
2. Correct the conditions that cause gas absorption during melting, holding and pouring — degas thoroughly.
3. Avoid heavy sections that stay liquid for extended periods of time.

Fig. 9 — Tiny Surface Defects.

4. Do not cause excessive contraction by chilling too fast. Keep the die relatively warm.
5. Reduce rate of casting ejection. However, this reduces productivity and should only be done as the last resort.

Table 22 — Foliations

Classification:

Small leaflike metallic layers partially fused to the casting surface.

Causes:

Formed when a warmer metal stream meets a chilled metal deposit on the die walls, penetrates between the deposit and the wall, forming a thin layer of unfused metal over it. Also occurs when the thin fore-runners flowing along the die walls freeze and are covered a little later by streams of molten metal.

(Table 22 — continued)

Corrections:

1. Ensure that the die cavity is thoroughly clean before each injection.
2. Raise the die temperature to its correct level.
3. Increase ingate size to minimize the fore-runner effect.

Table 23 — Hard Spots

Classification:

Tiny areas on the casting that cause excessive tool wear.

Cause:

Presence of harder-than-normal locations in the base metal.

Corrections:

1. Use correct melting procedure, minimizing any turbulence, agitation or overheating.
2. Keep the molten metal surface thoroughly clean. The Al_2O_3 formed on the surface by oxidation and agitation coagulates and hardens into a crust upon continued exposure. This gets incorporated into the molten metal and forms hard spots.
3. Ensure that sludging is not responsible (due to the presence of intermetallic compounds of Cr, Ti, Mn or Fe).
4. Check if inclusions are non-metallic in nature. If so, freshly rammed furnace lining may be responsible.
5. Conglomerated masses of Al_2O_3 severely impair machining. Clean alloy with dry Cl gas (in alloys requiring magnesium, loss should be compensated for by a slight initial excess). This treatment is usually effective.

Table 24 — Machinability (Poor)

Classification:

Alloy causing excessive tool wear during machining.

Causes:

1. Use of incorrect alloy, e.g.,
   a) Increasing percentages of Si and Fe decrease machinability.
   b) Increasing percentages of Cu (up to 12 per cent), Mg (up to 10 per cent), Ni, Sn and Pb, within limits, improve machinability.
2. Presence of Al_2O_3 in metal.
3. Porosity due to absorbed gas or turbulence.
4. Presence of hard spots.

Corrections:

1. Employ a more suitable alloy, if other conditions are favorable.
2. Eliminate drossing and formation of Al_2O_3 (refer).
3. Eliminate causes of porosity (refer).
4. Correct hard spots (refer).

Table 25 — Machined Appearance (Poor)

Classification:

Usually irregularities, often not due to oxide hard spots.

Causes:

Presence of sludge particles and other inhomogenities in metal.

Corrections:

1. A machined surface is not unduly disrupted by unseen particles of sludge. However, the surface displays varying degrees of brightness due to sludge precipitation. Basic causes of sludging must be eliminated (refer).
2. Remove causes of gas absorption and porosity (refer).
3. Check if hard spots (refer) cause drag lines.

Table 26 — Mechanical Properties (Low)

Classification:

An inherent loss of strength.

Causes:

Weakness of the casting due to:

1. Wrong composition.
2. Unsoundness due to porosity or inclusions.
3. Other incorrect treatment.

Corrections:

1. Analyze the molten alloy regularly for impurities in excess of the maximum specified, e.g., Si in high Mg or Mg-Zn alloys, or Mg in high Si alloys or excessive Fe, etc., in alloys where highest elongation is desired. Bring any impurity over the designated limit to within tolerance by dilution or usage of high grade ingots.
2. Based on the above, make sure that there is no chance of the re-usable returns of different alloys getting mixed.
3. In high Fe alloys (over one per cent addition of Mn improves ductility and strength. However, over 0.3 per cent Mn, castability decreases, sludging increases.
4. From the above analysis, also check regularly whether the main constituents are within the desired range. If not, sludging might be present (refer).
5. Avoid overheating of the die or metal that will result in a coarse grain structure. Grain refining is usually not necessary because of the die chilling effect. Coarse grains are sometimes caused by excessive Fe (over 1.4 per cent in die castings) specially in high Si alloys.
6. Eliminate the factors that would form oxides and result in oxide inclusions by fluxing molten metal with Cl_2 and avoiding storage of ingot outdoors or in contact with chlorine or other furnace fumes. In developing "oxide lines" or areas where oxide conglomeration forms "microstress raisers,"

(Table 26 — continued)

the casting can lose a considerable percentage (up to 40 per cent) of its mechanical properties.

7. Correct the causes of porosity.
8. Over modification with Na lowers properties. Modification is not normally required for die castings.
9. Die castings are not usually heat treated, but if so designated, do not overage above the recommended temperatures and times.
10. In higher Mg alloys, avoid excessive degassing with Cl_2 as this tends to remove Mg.
11. If the die injection pressure is low or nonexistent, e.g., if a thick (approx. 0.020 in.) flash is obtained, the metal is not at its designated high pressure and instead of obtaining a high strength die casting a lower strength permanent mold casting is obtained. Therefore, make sure that normal die casting pressures are employed and that excessive flash is not formed.
12. Sound die castings usually have superior mechanical properties. However, if low mechanical properties are observed and they are not caused by porosity, a low temperature heat treatment of parts may increase mechanical properties to their normal desired ranges. Generally stress relieving a part at about 300-350 F (148-177 C) for 5-10 hr (approx.) improves properties.

Table 27 — Platability (Poor)

Classification:

Poor surface appearance upon plating, due to inferior adherence.

Causes:

Presence of nonmetallics in casting surface, e.g., tiny particles or agglomerated masses of Al_2O_3. Poor basic surface or improper surface treatment (which also results in poor polishability).

Corrections:

1. Use Cl_2 gas for adequate fluxing of oxide particles during melting.
2. As unrefined solvent in the die lubricant causes oxide-slag lines due to unvolatilized hydrocarbons, these act as hard spots during polishing and nodes during plating. Hence the solvent employed should be highly refined and must completely volatilize below the regular die temperatures, 450-600 F (232-316 C).
3. Though the segregation of high melting point constituents (sludging) does not always disrupt a machined surface, an uneven sheen and surface often results, which leaves a surface with ridges. This effect is magnified upon plating. Factors which cause sludging must be eliminated.
4. Furthermore, as the plating bath is set for adherence to an Al base, any Fe-Mn-Si-Al complex will cause a bubble effect in the casting. Again the factors which cause sludging must be eliminated.
5. Degrease and clean surface well before plating.

Table 28 — Polishability (Poor)

Classification:

Casting surface having a rough, dull or nonuniform appearance.

Causes:

Rough die surface due to wear, resulting from molten alloy impact and/or constant wear caused by mode of injection. Failure to polish and maintain the dies at frequent, regular intervals. Excessive die or metal temperatures. Incorrect alloy. Factors causing defects like roughness, die soldering, hard spots flow lines, etc.

Fig. 10 — Defects in casting surface caused by hair cracks in die.

Corrections:

1. If necessary, correct die design to minimize die surface wear by molten alloy injection.
2. Obtain the highest die hardness commercially feasible, by heat treating the whole die without taking undue chances of cracking the same.
3. Nitrided and surface hardened cavity areas tend to dissolve or flake off. They also have to be smooth. Usually employed only on cores, etc.
4. Maintain consistently the degree of die surface finish necessary for obtaining a good casting surface.
5. Investigate a better die cavity coat that could possibly reduce die wear.

(Table 28 — continued)

6. Ensure that excessive alloy and die temperatures are not causative.
7. Employ an alloy with better polishability, e.g., generally speaking, alloys high in magnesium have good polishability, followed closely by those high in zinc and to a lesser extent nickel and copper. With an increase in Si content, this property deteriorates.
8. Check if die soldering, flow lines, seams, roughness and poor anodizability, etc., are responsible.
9. Tiny particles or conglomerated masses of Al_2O_3 cause tearing and pile up of miniature "pinnacles." Hence cleanse molten metal of oxides by Cl_2 gas flux.
10. Unvolatilized hydrocarbon resulting from the unrefined solvent in a lubricant can cause oxide-slag lines or hard spots. Use correct solvents that are highly refined which volatilize below normal die temperatures, 450-600 F (232-600 C).
11. Sludging in an alloy gives a buffed surface with an uneven sheen and ridges. Eliminate factors causing sludging.

Table 29 — Scratches

Classification:

Casting surface marred by obstruction to casting ejection.

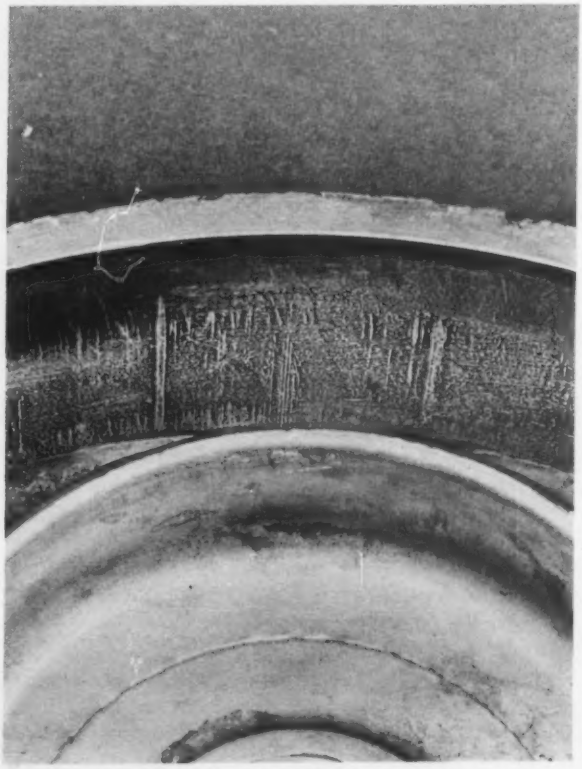

Fig. 11 — Scratches observed on the side of a casting due to contraction on and withdrawal from a core.

(Table 29 — continued)

Causes:

Incorrect die design or injection procedure.

Corrections:

1. If the scratches are always in the same location, check and correct the die.
2. If they are not always in the same location but are oriented in the direction of ejection from the die, usually deep at the starting end, short in length and tapering off until they disappear, they are caused by metal splash during injection. Alter the shot velocity and/or open the gate so that no splash can precede the main metal shot.

Table 30 — Stains

Classification:

Discoloration of the surface.

Causes:

Presence of $CaCO_3$, $CaSO_4$, $CaCl_2$ or free Fe in water soluble mold coating or coolant or casting quenching mediums. Graphitic suspensoid type of coatings, lubricant contamination and high temperatures also cause this effect.

Corrections:

1. If water soluble coolant is used, sequester the offending material by adding 8 oz of sodium hexametaphosphate to 50 gallons of coolant.
2. Use a mineral seal or kerosene for dipping or spraying the casting.
3. If observed directly after ejection from the die, check whether caused by lubricant contamination or die coat. Eliminate the cause.
4. If excessive metal and die temperatures are responsible, check and correct.

Table 31 — Streaks

Classification:

Streaks observed usually in front of a gate, more grayish in color than the base metal, both of them possessing the same chemical composition.

(Table 31 — continued)

Cause:

First spurt of metal into the die solidifies immediately and is covered by rest of the metal. This causes a difference in the dispersion size of the Si particles.

Corrections:

1. Change size and/or location of ingates in a way to prevent presquirting of the metal.
2. Change direction of injection into cavity.
3. Raise temperature of the die and make it more uniform in every part of the die cavity.
4. Check if lower injecting piston speeds (keeping pressure the same) will decrease this defect.

Table 32 — Warpage

Classification:

Castings distorted over their permissible tolerances.

Causes:

1. Uneven contraction during solidification or eventual cooling.
2. Unbalancing of internal stresses by machining.
3. Uneven physical support when cooling.

Corrections:

1. Improve faulty mold design (if possible) such as abrupt changes in section, unbalanced casting design, etc., shown by uneven location of ribs, bosses, etc.
2. Check for uneven ejection of the casting from the die.
3. Eliminate improper (uneven or sudden) cooling of the casting after ejection.
4. Ejected castings should not be stacked with uneven support or piled haphazardly, especially if they are large and bulky.
5. If warping is accentuated upon heat treatment (when specified) place castings in or on an adequate fixture.
6. When heat treatment is required, use a less drastic operation (if possible).
7. To correct warpage, heat to 600-650 F (316-343 C), clamp in a correcting vise or fixture and allow to slow cool. Keep in mind any prior or subsequent heat treatment.
8. As far as possible, avoid machining the outer skin causing unbalancing of the internal stresses.

CONCLUSION

As with any other program of product improvement, quality control or scrap reduction, a system for betterment necessitates a well organized plan. It must be thorough, precise, yet simple. Since operating conditions are dynamic, each problem has its own peculiarities and will merit individual consideration based on the varied recommendations offered above.

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SHOOTER, CEROXIDE, CERMET OR SLAG

by C. A. Sanders, H. J. Heine and R. F. Marande

ABSTRACT

It has been found that porosity, pin holes and gas holes are often associated with a fluid and gassy slag, which can usually be seen floating on the iron along the walls of delivery and pouring ladles. The nature and origin of the fluid slag is discussed at some length. Effective and practical means of controlling this potential threat to good castings are suggested. Good ladle practice including lining, care and skimming are the most important control methods.

INTRODUCTION

In the past few years malleable foundries have given many different reasons for porosity, pin holes and gas holes. A previous investigator[1] has divided pin holes into two different causes—"evolution" and "reaction." It has been felt that reaction pin holes warrant a closer investigation. Recently, several observers have begun to associate these defects with the presence of certain types of slag, especially in bull ladles and pouring ladles. Slag inclusions as such take their toll in scrap castings, but often inclusions from many sources are lumped together under the heading of "dirt."

This paper will attempt to isolate one type of slag that is particularly annoying to foundrymen because of its extreme fluidity at ordinary pouring temperatures. This type of slag is always a potential threat, even though it appears only in sprues and runners but not in the castings. An effective and practical means of controlling this fluid slag before it reaches the mold will be suggested. This thin, watery slag has appeared on distribution and pouring ladles, and has been given different names by different observers. Some of these names appear in the title, and all are indicative of the observed behavior or property of this type of slag.

The name "shooter" derives from the fact that this slag is usually associated with gas, and can sometimes be seen in the ladle or pouring basin actually evolving gas and jumping about in a wild state of agitation. The names "cermet" and "ceroxide" refer to the composition found by some chemists. The former suggests a combination of ceramic and metallic origin, while the latter suggests a combination of ceramic oxides. However, the writers prefer the more prosaic name of "gas-slag" as describing more closely the observed effects.

One type of slag which was found on top of a riser after solidification is shown in Fig. 1.

Fig. 1 — Slag defect removed from the top of a riser.

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Fig. 2 — Ceroxide defect in a steel casting.

CEROXIDES IN STEEL FOUNDRIES

Many steel foundrymen claim that the "ceroxide" inclusions found in steel castings are peculiar to their industry. Sanders was among the first to recognize and describe the "snotter" defect.[2] This unpopular defect has been shown to be a slag inclusion,[2,3,4] which appears principally on the upper surfaces of steel castings and is often more serious in small than in large castings. This is because the inclusion may be found below the surface on the smaller or thinner section castings.

It has now been confirmed by petrographic analysis that the so called "snotter" is a slag inclusion, and its origin is likely in the deoxidation process. This is particularly true where aluminum is the deoxidant. An example of a "ceroxide" defect in a steel casting is shown in Fig. 2.

CERMETS OR GAS-SLAG IN MALLEABLE PRACTICE

In recent years the malleable industry has begun to realize that it too has a slag problem. By slag we do not mean the ordinary viscous slag that can be easily removed from the ladle with a skimming rod. We refer to the thin, watery slag that is sometimes difficult to see and defies most conventional methods of removal. Several foundries have volunteered their observed information and remedies for this troublesome problem. It has been found that if this thin slag is not controlled it may result in a high incidence of scrap due to gas and pin hole porosity and blows.

Numerous malleable castings, sprues and runners have been studied, which clearly show the results of the gas-slag condition. If the risers and runners are examined before cleaning, the defect, if present, will be found covered with a scale of varying thickness usually on the upper or cope side. When the scale is broken with a suitable scraper, a smooth surface is usually found covered with a blue oxide film. There is always a space between the scale that can be broken off and the smooth surface underneath. It is presumed that this space was formed by gas. The brittle scale portion of this defect seems to adhere and merge completely with the sand or core surface with which it has come in contact.

SPRUE AND RUNNER STUDIES

It has been observed that a thin slag sometimes forms at the edges and lips of pouring ladles and flows into the mold. This slag has been described as having the appearance of molten wax. Sprues and runners have been checked on molds that this slag entered during pouring. Some observers claim that during slag inclusion troubles, feeder heads may also show evidence of these unusually fluid slags. These slags will remain liquid even after the metal has solidified. An example of this condition has been found in Y, T and L sections where the slag, if present, will exude as the metal solidifies, leaving the slag deposit on the outside. A typical appearance of this type is shown in Fig. 3.

The analyses of a number of slags, which have been taken from runners and sprues and associated with blows, gas and pin holes, were found to vary within the limits shown in Table 1.

TABLE 1 — GAS-SLAG FOUND IN RUNNERS AND SPRUES

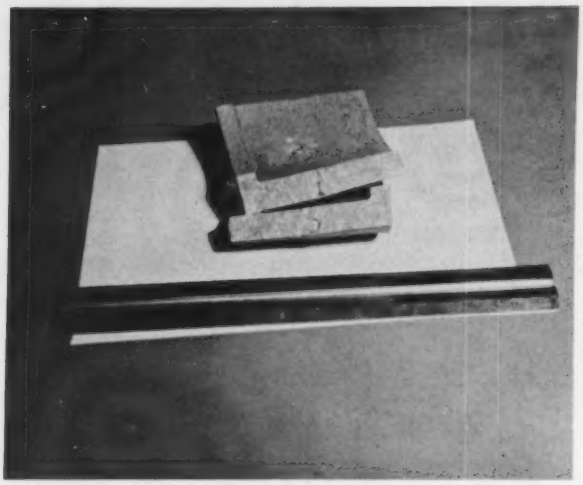
SiO_2, %	40 to 54
Al_2O_3, %	6 to 21
FeO, %	20 to 26
MnO, %	6 to 17
CaO, %	0.1 (approx.)
MgO, %	1 to 5

During the same period another sample was taken of the mushy accumulation formed in the bottom of a pouring ladle while being preheated. This sample was analyzed for iron oxide only and was found to contain 34.6 per cent.

FURTHER GAS-SLAG STUDIES

Many foundrymen have observed the buildup and accumulation near the top of pouring and distribution ladles. This buildup can get so severe that it will actually cut down the capacity of the ladles. Samples of this buildup material have been taken from the pouring and distribution ladles with the results shown in Table 2.

It is important to note the high proportion of manganese oxide and iron oxide in these samples. Both of these oxides greatly increase the fluidity of slags in which they are found. Furthermore, the oxide can



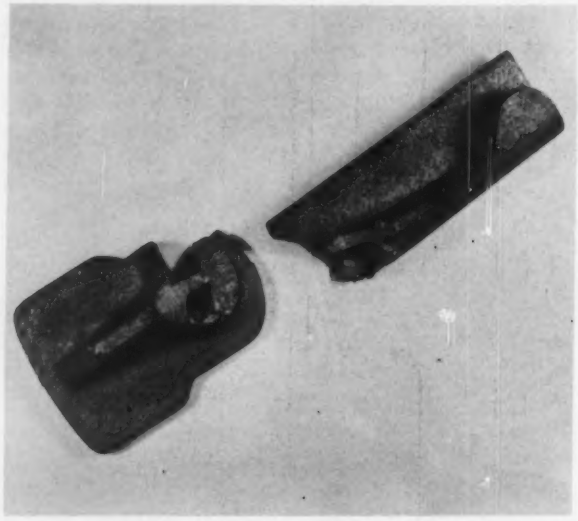


Fig. 3 — Typical defects caused by ceroxide or gas-slag in malleable iron.

TABLE 2 — LADLE BUILDUP ACCUMULATION

	Pouring Ladle, %	Distribution Ladle, %
SiO_2	63.3	72.4
Al_2O_3	10.2	10.3
FeO	20.6	14.3
MnO	2.4	1.8

react with carbon present in the iron and in the mold to generate gas as follows:

$$FeO + C \rightarrow CO + Fe$$

The relationship between the observed facts and the form of the gas-slag defect seem more than coincidental. Furthermore, the high iron oxide content of the buildup in the ladles fits the observation of a fluid slag and gas in the gas-slag defect as well as the analysis of the defect scale. Foundrymen have had a tendency to ignore the reactions between metals and refractories until quite recently. However, it was shown by Colligan[4] that a reaction may occur between iron and silica through the process of metal oxidation resulting in FeO.

AIR FURNACE SLAGS

The possibility that this fluid slag could come from the furnace should not be overlooked. Furnace linings are open to attack from many sources, such as the ash from the coal used as fuel or from soda ash used as a desulfurizer in the furnace. If soda ash is used, it should not be left on the bath more than 15 or 20 min. It should then be thoroughly removed by skimming. If a fluid slag persists, a ground brick grog or other siliceous material added to the bath is used by some operators to cut down erosion and facilitate removal.

In general, however, it is believed that good malleable air furnace practice will effectively prevent appreciable amounts of slag from being carried through the tap hole with the metal. The slag which collects on the furnace bath should be removed as it forms and not allowed to accumulate. The slag should be removed as completely as possible toward the end of the heat, so that a considerable amount will not be left in the furnace after it is drained. The analysis of the iron should be controlled at the end of the heat in other ways than by a slag cover.

All the iron should be removed from the furnace at the end of each day's run to minimize oxidation on reheating. A typical furnace slag skimmed from an air furnace used for duplexing malleable iron is:

Analysis, %	
SiO_2	45.50
Al_2O_3	32.46
FeO	12.24
MnO	4.18
CaO	0.42
MgO	3.04

It will be noted that this slag also has a high amount of iron oxide and manganese oxide similar to that found on the ladles. Any fluid slag forming along the walls of the furnace, however, should be swept toward the back due to the action of the flame and combustion gases. Also the iron is tapped from the hole several inches below the surface of the furnace bath, which should preclude the possibility of an appreciable amount of the fluid slag being carried out of the tap hole.

Furthermore, if much of this fluid slag were leaving the furnace through the tap holes, all experience with slags indicates that this would soon enlarge the holes. This is not the case, since the tap out blocks are used for at least five days without any sign of enlargement. Oxidized metal can also collect along the sides of the furnace spout. This should be knocked off as often as possible before it has a chance to penetrate the refractory and contribute to the slag problem in the ladles.

Fig. 4 — Downsprue, after cleaning removed the slag.

FERRO-ALLOYS, OXIDATION AND DEOXIDATION

Some foundries have reported that excessive additions of ferromanganese and/or ferrosilicon to liquid white iron can be responsible for creating slag problems. In this case, the cause and the remedy lie in the conditions that make it necessary to add large amounts of ferromanganese and ferrosilicon to the air furnace. The cause is usually excessive oxidation in the cupola in duplexing processes or faulty flame control in the cold melt air furnace process. Two of the most common causes of excessive oxidation in the cupola are bridging, and failure to keep the stack full.

Bridging can usually be corrected by an analysis of the problem. This may involve proper sizing of materials, fluxing practice, and lining practice. Failure to keep the cupola stack full is inexcusable and should not be tolerated, since it will invariably result in excessive loss of manganese and silicon. Therefore, it should be clear that any ill effects caused by large additions of silicon and manganese are the result of an oxidizing condition that should not have been allowed to occur.

Another factor that should be taken into account when excessive amounts of ferrosilicon are used is the aluminum content of the latter. This aluminum content can contribute to the slag inclusion problem in the same way that aluminum deoxidation does in steel practice. It is generally believed that the aluminum content of molten iron should be kept below 0.001 per cent to avoid certain pin hole defects. This can usually be accomplished by specifying the maximum percentage of aluminum that will be acceptable in ferrosilicon.

GATING SYSTEMS

It is certainly important to have good gating practice. However, a good gating system which will trap most ordinary slags will not be too effective in stopping the fluid, watery, slag that has been discussed in this paper. The observations which follow will show that this fluid slag must be kept under control ahead of the mold to be effective.

Observations on Ladles and Pouring

At one point during the many tests and observations on the gas-slag problem a pouring ladle in which an unusually large amount of foamy, fluid slag had formed was noticed. A mold was deliberately poured without trying to remove the slag. The sprue, runner and casting showed not only the common refractory slag but also a severe gas-slag condition.

Shortly after the above observation four molds consisting of a 10 in. by 10 in. by ½-in. plate were poured. The first two were poured with a ladle that had accumulated a large amount of fluid slag. The third mold was poured from a clean ladle, and with what appeared to be clean iron. The fourth was also poured with clean iron, except that scale from the gas-slag defect collected from the sprues and runners of previous tests was added to the ladle. This latter immediately developed a thin foamy slag before pouring.

Of these plates the first two showed both common slag and gas-slag. The third was clean. The fourth showed the gas-slag condition. The occurrence of the two types of slags in the test castings indicated two types of slag in the ladle. Close observation of the pouring and distribution ladles revealed the two types. The more common is the viscous slag, which will usually segregate and collect in the center of the ladle. The other type is that which can be seen actually forming against the ladle walls. It is sometimes foamy but is always fluid.

It is this second type which causes the gas-slag defect. This was confirmed by observing the pouring of 20 molds with ladles on which the fluid slag was present in considerable quantity. Without exception, the sprue and runners contained the gas-slag defect when the thin, fluid slag was seen entering the mold. An example of the appearance of a downsprue, after cleaning removed the slag, is shown in Fig. 4.

Another observation that was significant concerned the buildup on the walls of ladles mentioned earlier. If the distribution ladles were not skimmed, this buildup would soon reduce the capacity of the ladle appreciably. One morning a ladle with considerable buildup was filled with iron at the furnace after a suitable preheat. Immediately afterwards, two ladles newly lined with a dense silica material were filled with iron.

A large amount of fluid, foamy slag formed on the older ladle with the buildup. The two new ladles were perfectly clean. The contrast was striking. The ladle with the large amount of slag was pigged and then refilled. It still contained too much slag to be

Fig. 5 — Distribution ladle being skimmed.

Fig. 6 — Pouring ladle being skimmed.

usable and the contents were again pigged. It was then noted that the ladle capacity had considerably increased. In other words, a large amount of the buildup material had floated up as slag. The newly lined distribution ladles continued to show little slag. These observations were strong evidence showing that the origin of the fluid slag was in the ladle, and that the gas-slag defect was a product of the oxide buildup in the ladles.

Remedies for Control of the Gas-Slag Condition

After reviewing the above tests and observations, it was concluded that the only practical place to control the gas-slag problem and minimize the threat to good castings, is in the ladles. This means that strict and systematic ladle practice must be set up. These items have proved helpful and important in maintaining clean ladles:

1. Number all ladles, preferably by welding on the yoke or bowl.
2. Select a refractory material that can be rammed to a dense lining.
3. A lining material that will gradually erode away is preferred to one that is too refractory.
4. Keep a record of the number of days each ladle is used.
5. Skim all distribution and pouring ladles every time they are filled with iron. This should be done as thoroughly as practical starting with the first time the ladle is used.
6. Establish a maximum number of heats after which ladles will be relined.
7. Make sure that all iron is poured out of the ladles after using. Even small amounts of iron will be oxidized readily on cooling and reheating and contribute to fluid slag formation.

Illustrations of distribution and pouring ladles being skimmed are shown in Figs. 5 and 6.

CONCLUSIONS

1. *Cause.* The gas-slag defect is caused by a fluid slag which clings to mold walls and generates gas through chemical reaction with carbon in the iron or in the mold.
2. *Source.* The slag which causes the gas-slag defect is produced by continual self fluxing of oxide accumulations in the furnace spout, distribution ladles and pouring ladles.
3. *Control.* This fluid slag can be prevented from ever becoming a threat to good casting production by good ladle practice outlined, and by thoroughly skimming ladles to prevent any accumulation of slag.

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NEWS and VIEWS

Use Names of Cities in Show
Outline Gating Principles
Start New Test Standards

Assign Chapters to AFS Directors

Administrative assignments have been made for the seven AFS regional divisions. This includes naming Regional Vice-Presidents who serve as official AFS representatives and the assignments for chapter contacts. The division into geographical areas permits a decentralization of administration from the Central Office in Des Plaines, Ill.

The regional assignments:

Region 1—Regional Vice-President R. R. Ashley. Chapter contacts, Ashley—Connecticut, New England, M.-I.T. Student Chapter, and Wentworth Institute. D. E. Best—Chesapeake, Metropolitan, Philadelphia, Piedmont, and Brooklyn Polytechnic Institute.

Region 2—Regional Vice-President W. H. Oliver. Chapter contacts, Oliver—Northwestern Pennsylavania, Western New York, Pittsburgh, and Penn State University Student Chapter; D. E. Webster—Central New York, Eastern New York, Rochester, and Southern Tier Section if organized; A. J. Moore—Eastern Canada, Ontario, and Ryerson Institute Student Chapter.

Region 3—Regional Vice-President R. E. Mittlestead. Chapter contacts, Mittlestead—Canton; W. E. Sicha—Central Ohio, and sharing representation of Northeastern Ohio with D. L. Colwell; D. L. Colwell—Toledo; AFS President A. L. Hunt—Ohio State University Student Chapter.

Region 4—Regional Vice-President T. T. Lloyd. Chapter contacts, Lloyd—Central Michigan and Michigan State University Student Chapter; C. O. Schopp—Central Indiana, Cincinnati, and Michiana; E. C. Jeter—Detroit and University of Michigan Student Chapter; C. J. Lonnee—Saginaw Valley and Western Michigan.

Region 5—Vice-President N. N. Amrhein. Chapter contacts, Amrhein—Wisconsin with M. E. Nevins, and University of Wisconsin Student Chapter; R. J. Hageboeck—Central Illinois and Quad City; J. T. Moore—Chicago with N. J. Dunbeck; M. E. Nevins—Twin City and Northern Illinois-Southern Wisconsin; AFS Vice-President J. A. Wagner, University of Illinois Student Chapter.

Region 6—Vice-President W. C. Jeffery. Chapter contacts, Jeffery—Birmingham, Mid South, Tennessee, and University of Alabama Student Chapter; AFS President A. L. Hunt—Mexico; Charles Ossenfort—Corn Belt, Mo-Kan, St. Louis, and University of Missouri Student Chapter. Dale Hall—Texas, Timberline, Tri-State, and Texas A & M University Student Chapter.

Region 7—Vice-President A. E. Falk. Chapter Contacts, Falk—Northern California; and Utah; J. N. Wessel—British Columbia, Oregon, Washington, and Oregon State University Student Chapter.

Chapters Schedule Regional Conferences

Six regional conferences will be sponsored by AFS chapters during September and October.

The conferences scheduled:

Missouri Valley Regional **Sept. 21-22**
Missouri School of Mines, Rolla, Mo.

East Coast Regional **Sept. 22-23**
Statler-Hilton Hotel, New York

Ohio Regional **Oct. 5-6**
Netherland Hilton Hotel, Cincinnati

New England Regional **Oct. 13-14**
M.I.T., Cambridge, Mass.

Michigan Regional **Oct. 19-20**
Michigan State University, East Lansing, Mich.

Purdue Regional **Oct. 26-27**
Purdue University, Lafayette, Ind.

Chapter Officers

Officers from the Society's chapters in the United States, Canada, and Mexico met June 15-16 in Des Plaines, Ill., and Chicago. Highlights of the meeting will be found in Looking at Business, page 7, and the Editor's Forum, page 134.

Technical Council Outlines Program

Research activities for the coming year were outlined at the annual meeting of the Technical Council. Attending were chairmen and vice-chairmen of the technical divisions and general interest committees.

The expanding program includes new research and publications, extensions of some existing programs, and creation of new committees within the division framework.

Cooperative efforts are continuing with other technical societies. The Permanent Mold & Die Casting Division is jointly sponsoring a research program on fluid flow with the American Zinc Institute and the American Die Casting Institute. "Refractories as Sources of Macroinclusions," a Steel Division sponsored research project at the University of Michigan, written by L. J. Van Vlack, J. E. Brokloff, and R. A. Flinn, will be re-presented at the American Institute of Mining and Metallurgical Engineers Electric Furnace Division this fall.

Several publications are in progress or are contemplated. These include a new manual on refractories, light metals sand casting, and brass and bronze casting practices. J. B. Caine has offered his services in writing a book on casting design with the assistance of the technical divisions.

AFS President A. L. Hunt spoke at the luncheon and presented certificates of appreciation to retiring technical division and general interest committee chairmen. Those retiring are J. G. Mezoff, Light Metals; R. B. Fisher, Brass & Bronze; Jess Toth, Education; R. A. Clark, Gray Iron; F. W. Jacobs, Malleable Iron; J. M. Kreiner, Pattern; F. C. Bennett, Die Casting & Permanent Mold; H. G. Haines, Ductile Iron; D. N. Rosenblatt, Steel; W. K. Bock, Heat Transfer Committee; and C. F. Joseph, Cupola Advisory Committee.

The new division and committee chairmen:

Brass and Bronze—Chairman R. A. Colton; Vice-Chairman F. L. Riddell.

Education—Chairman, J. L. Leach; Vice-Chairman, G. E. Garvey.

Gray Iron—Chairman, H. E. Hen-

Certificates of appreciation were awarded to outgoing division and general interest committee chairmen. AFS Education Director R. E. Betterley, right, makes presentation to Jess Toth, center. Prof. J. L. Leach, left, succeeds Toth as chairman of the Education Division.

A between meetings lull permits a brief discussion between AFS Technical Director S. C. Massari, left, AFS General Manager Wm. W. Maloney, center, and AFS President A. L. Hunt.

derson; Vice-Chairman, H. E. Barnum.

Light Metals–Chairman, S. Lipson; Vice-Chairman, C. R. Howle.

Malleable–Chairman, L. R. Jenkins; Vice-Chairman, D. L. LaMarche.

Steel–Chairman, W. A. Koppi; Vice-Chairman, G. A. Colligan.

Die Casting & Permanent Mold–Chairman, R. P. Dunn; Vice-Chairman, N. Sheptak.

Ductile Iron–Chairman, D. Matter; Vice-Chairman, A. H. Rauch.

Pattern–Chairman, R. L. Olson; Vice-Chairman, W. E. Mason.

Heat Transfer Committee–Chairman, R. E. Spear.

Cupola Advisory Committee–H. W. Gorman.

Refractories Manual Committee Chairman John Zotos, left, shows H. J. Weber, AFS Director of Safety, Hygiene and Air Pollution, the amount of work done to date on the new manual on refractories. This is one of several publications underway or contemplated during the next technical year.

Circle No. 141, Pages 129-130 ➡

service

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Circle No. 142, Pages 129-130

Use World Cities in AFS Show Plan

Foundrymen from Austria to Zanesville, Ohio, will find a touch of home at the AFS 66th Castings Congress & Exposition to be held in May, 1962, at Cobo Hall, Detroit. The Congress & Exposition will be held in conjunction with the International Foundry Congress.

Conventional aisle numbering for the Exposition has been eliminated by AFS Convention & Exhibit Manager Dick Hewitt. Instead, each aisle will bear the name of a famous city in the United States, Canada, Mexico, or foreign country.

Twenty-two will have names of U.S. cities and a like number for prominent cities in countries belonging to the International Committee of Foundry Technical Associations. In addition, there will be two from Canada and Mexico.

"Because everyone is accustomed to locating business establishments by street number, it is hoped that this will help foundrymen to find exhibitors they wish to visit," comments Hewitt.

To further aid exhibitors and visitors, two special information booths will be located at prominent midpoints of the show. Attendants will assist in locating exhibitors by flashing a "Your are Here" sign and tracing the route with a red glow pencil which will shine through the transparent plan.

Start on New Test Standards

Preliminary work on tentative standards for the furan-hot box core test procedures has been started by a Sand Division Sub-Committee. This includes:

Sand Coating Procedure—Mixing the catalyst into sand before adding the binder was recommended to prevent excessive concentration of the catalyst from contact with the resin. Mix one minute. The temperature of sand to and from the muller is important and the range of temperatures will be recommended.

Working Time of Coated Sand—The sub-committee is to determine differences in working time between sealed and open samples, however, most sand is stored in hoppers. Additional test data is needed to determine working time or bench life, such as the stripping strength vs. time for 5-second intervals up to 60 seconds and tensile strengths on samples stored up to 8 or 24 hours. Storage temperature range such as 70-90 F. is also essential.

Blowing Pressure in Specimen Forming—The sub-committee recommends 80 pounds line pressure for blowing test cores.

Temperature Control of Sand and Specimen Forming Patterns—To keep sand at proper temperature, muller charging and discharging temperature ranges should be established. Accurate control of pattern heat is necessary to give close control of the specimen temperature.

Procedure for Forming and Testing Specimens—The sub-committee studied an experimental hot-tensile tester. It was suggested blowing through the top plate of this tester and to use only for stripping strengths, maximum 200 lb, and not include cold tensile strength, maximum 800 lb, to lower cost of the tester. Proper control of pattern temperature is important, 300 or 500 F. can be used. Four tests are to be made at each curing time with the following sequence suggested: 5 sec, 10 sec, 15 sec and return to 5-sec cores.

Stripping Time at Various Times and Temperatures—Normal time is from 5-30 sec in production with 60 sec the upper limit 120 sec of academic interest. The primary concern is only to have enough strength to strip without breakage.

Cold Tensile and Hardness of Cores at Various Times and Temperatures—A specific set time before testing is necessary, somewhere between 1/2 and 1 hour before breaking cold tensiles. It was suggested warm (cooling) specimen for tensile strength to obtain rate-of-cure tests, from hot-stripping temperatures to room (cold) testing. Under constant cooling conditions (no draft) tests can be made every 5 min to determine when the core has properly cured for washing and dipping, temperatures to be taken immediately after cores are broken. Another recommendation was a moisture-resistance test using a sealed container with water in the bottom (100 per cent relative humidity) for storing cores cured at different lengths of time, curing at 400 F., before breaking.

Depth of Cure—This property may be related to tensile strength on the basis of stripping strengths. A 1-in. specimen should be used for depth of cure tests to get breaking strengths in the range of commercial testers and reduce the amount of resin.

Other Sand Division activities included:

Tentative procedures were outlined by the No Bake Core Binders Testing Procedures Sub-Committee. Where applicable, the procedures for oil-oxygen binders are to be used.

Working Time—The tentative procedures consists of making up a series of 2x2 in. cores and placing them on curved dryer plates so that specimens rest on the side rather than the end. Green compression strengths are determined on these specimens at 5-min intervals. The time at which a significant increase in green compression strength was obtained was the length of working time or "bench life."

Stripping Time—Several procedures were outlined for determining the depth of set or the length of time necessary to hold the core in the box to prevent sagging or distortion. One method is to use a tapered metal waste basket, and hand jolt. Another is to use a specially truncated cone box, 12 in. long, 4 in. wide at the largest diameter and 2 in. wide at the smallest diameter. This box is rapidly filled with sand and hand jolted. Stripping time in both methods was the minimum time that the core had to remain in the box without obtaining sagging or distortion after the core was removed from the box.

It was suggested that a thermometer be inserted into the core to determine the rate of exothermic reaction. However, before either of these two methods can be adopted as standard, the method of ramming must be more clearly defined.

Curing Time—Several methods were suggested for determining curing time or the time before the core can be moved from the plate after stripping of the box. One method is to use the truncated cone box and checking hardness along the sides as soon as the box is removed. Another is to use a vent wire to determine the depth of set. A third method is to ram up a series of cores in paper cups and determine the length of time it requires to obtain identical hardness on the top and bottom of the specimen.

East Coast Regional Set for Sept. 22-23

New Frontiers in Metal Castings has been selected as the theme of the East Coast Regional Conference to be held Sept. 22-23 in New York.

Technical sessions will be held for steel, gray and ductile iron, aluminum and magnesium, brass and bronze, and malleable iron. Thirty speakers will address the sessions. The conference is sponsored by the AFS Metropolitan, Philadelphia, and Chesapeake Chapters. R. B. Fischer, Ingersoll-Rand Co., Phillipsburg, N. J., is general conference chairman.

All sessions will be conducted at the Statler-Hilton Hotel. Friday's schedule includes registration starting at 8:30 am, technical sessions from 10:00 am to noon, continuing from 2:00 pm to 5:00 pm. On Saturday, registration will start at 8:30 am with technical sessions conducted from 9:30 am to noon.

Betterley Addresses Education Conference

Suggestions for improving industrial shop course programs were advanced by AFS Educational Director R. E. Betterley at a recent industrial education conference held at Iowa State University.

Included in his presentation was a showing of the AFS film "Cast Metals and You," and colored slides with representative castings made in high school industrial arts shops.

More than 200 teachers, directors, and supervisors of industrial education from a five-state area attended.

Stress Gating, Risering Principles in Course

Theory and practice of gating and risering non-ferrous and ferrous metals will be presented by the AFS Training & Research Institute July 17-19 in Chicago. Those attending are encouraged to bring specific problems for evaluation.

Included in the course will be metal flow, mechanics of solidification, heat transfer, shrinkage, hot tears, ferrostatic pressure, gate and riser design, mold wall movement, and turbulence.

Stress will be placed on calculation of riser size, pouring times, and the placement and feeding distance of risers.

Course No. 10, "Gating and Risering of Castings," is intended for foremen, patternmakers, foundry engineers, supervisors, industrial engineers, and quality control personnel. Course fee, $60.

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Circle No. 143, Pages 129-130

CHAPTER NEWS

Auburn Foundry Laboratory Gets New Furnace

Cooperation by the AFS Birmingham Chapter and Westinghouse Electric Corp. has provided a new high frequency induction furnace at Auburn University, Auburn, Ala. This addition makes the modernization of the university foundry laboratory almost complete.

The AFS Birmingham Chapter contributed toward the purchase of the furnace and the motor generator was donated by Westinghouse Electric.

"Addition of this equipment makes the modernization of our foundry and metallurgical laboratory more complete for research and metallurgical instruction," said Dan T. Jones, head professor of Auburn's industrial laboratories. Jones, 70 years old, is retiring after serving Auburn almost continuously since 1913.

The Birmingham Chapter has been instrumental in assisting the university in modernizing its foundry laboratory. Harry Burns, vice-president, manufacturing, Stockham Valves & Fittings, Birmingham, has been a leader in this movement.

Student W. H. Stockham and Prof. D. T. Jones, check out the console of the motor generator for the new induction furnace.

Central Indiana Chapter

Issues Chapter History

A chapter history, dating back to preliminary planning in 1939 and admittance to the Society in January, 1940, has been completed. The first chapter chairman was I. R. Wagner who served as AFS President in 1952-53 and AFS Training & Research Institute Trustee from 1957-1963.

The history lists all officers, directors, and committee chairmen since the chapter's inception. It also carries highlights such as the activities of the foundry training committee, the setting up of the Purdue Cast Metals Conference, and career days for high schools.

National Director Carl Schopp is a former chairman of the chapter.

New England Chapter

Shell Molding & Shell Cores

Advantages, disadvantages and materials used in shell molding and shell core manufacturing were described by L. E. Wile, Lynchburg Foundry Co., Lynchburg, Va.

Advantages listed by Wile for cores were included: complicated shapes made easier; two or more cores can be combined into one; elimination of ovens, dryers, wires, and plates, reduced cleaning costs; infinite storage; excellent shakeout; excellent venting characteristics. Disadvantages of shell cores include: some peel back or lamination in large cores; softening or bending where there is not ample support or where heavy metal sections are encountered.

Advantages of the shell molding process include, said Wile: less machining, elimination of machining in many instances; elimination of a machine operator; more consistent dimensions; smooth surface initially and for subsequent operations; less weight, reduced tool wear; and better metallurgical properties. Wile said the main disadvantage of shell molding is the high cost of the process which can be partially offset by high production, use of unskilled or semi-skilled labor, reduced cleaning and finishing, storage of molds, and elimination of certain defects.

Wile stated that round grain sands give the highest strength for a given resin percentage but can be cheaper in the end because of reduced resins cost. Disadvantages may occur from an expansion, and thermal shock standpoint.

Angular grain sands are most commonly used. They should be clean and well graded. They are excellent for blending with round grain sands.

In discussing natural or bank sands, Wile said that a few grades, those low in clay and with a natural iron oxide and aluminum oxide are satisfactory. Care must be taken against too much clay since it absorbs resin. Other materials such as wood resins will accomplish the same purpose and add to, rather than distract from the efficiency of the resin.—by J. H. Orrok

Canton Chapter

Hears Talk on Sand Control

Adequate sand control methods are essential for quality control and reduction of scrap, stated George Vingas, Magnet Cove Barium Corp., Arlington Heights, Ill. Problems and their solutions were recommended by Vingas in an illustrated talk.—by Charles Stroup

Southern Tier Section

Elect New Directors

Directors have been named for the coming year. They are: Fred Allen, Tioga Foundry Corp., Owego, N.Y.; Floyd Wilhelm, Kennedy Valve Mfg. Co., Elmira, N.Y.; Richard Potter, Chemung Foundry Corp., Elmira, N.Y.; Fred Kuster, Ward Casting Co., Blossburg, Pa.; Peter Hopkins, Athens Foundry Corp., Athens, Pa.; and I.N. Kitchen, Painted Post, N.Y.—by Fran Troy

Ontario Chapter

Conducts Panel Program

For the convenience of chapter members living beyond the regular meetings places of Toronto and Hamilton, a technical meeting was held recently at Orillion. Speakers and members came from as far away as 240 miles.

Ted Skelly, American-Standard Products (Canada) Ltd., was moderator for a three-man panel. Members and their topics were: refractories, Larry Hansen, Malleable Foundry of Internationl Harvester Co.; new sand developments, Archie Jamieson, J. A. Wotherspoon & Sons, Ltd.; and time motion study, Ted Tafel, American-Standard Products (Canada) Ltd.—E. J. Skelly

Eastern Canada Chapter

Safety, Hygiene Problems

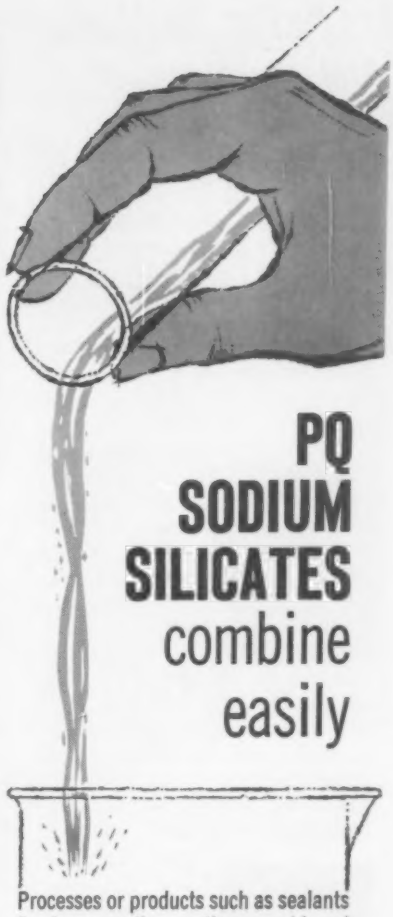
How AFS services can be utilized to meeting problems of safety, hygiene, and air pollution were outlined by H. J. Weber, director of the AFS program. Weber also discussed common foundry problems and recommended solutions.—by J. Cherrett

PHILADELPHIA—Foundry training in local vocational schools was discussed by Education Chairman P. J. Keeley and his committee. Seated are: J. Schraeder, Olney Foundry; E. X. Enderlein, H. G. Enderlein Co.; and Ed Saks, Dobbins Vocational School. Standing: Ed Zeeb, Dodge Steel Co.; John Gross, Dobbins Vocational School; P. J. Kelley, Northern Bronze Corp.; and J. Quigley, National Crucible Co.—by Leo Houser and Ed Klank

ST. LOUIS—Participating at a recent meeting were W. M. Peterson, M. A. Bell Co.; retiring chairman E. E. Hart, Great Lakes Carbon Co., chairman Dale Arnette, Arnette Pattern Co.; and speaker J. R. Hundley, Granite City Steel Co.—by W. E. Fecht

OREGON—Hydraulics of gating systems were explained by Prof. W. M. Miller, University of Washington, third from left. Others are William A. Meyer, William D. Clark, and George Gilmore, all of Esco Corp.

METROPOLITAN—Newly elected officers; Director L. W. Herbst, Semet Solvay Co.; Director K. M. DeFerrari, American Brake Shoe Co.; Secretary R. F. Hoffman, Worthington Corp.; Chairman R. V. Hunter, Archer-Daniels-Midland Co.; Director D. B. Slater, Whitehead Bros. Co.; Treasurer W. H. Ruten, Brooklyn Institute of Technology. Not present was Vice-Chairman J. D. Allen, Federated Metals Div., American Smelting & Refining Co.—by Walter Napp



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Circle No. 144, Pages 129-130

For Better Castings:

Add These Magcobar Men to Your Team

Behind Magcobar's high performing foundry bentonites are engineers, dealers, and sales personnel who are eminently qualified to help you use Magcobar's complete foundry service to improve your castings production. Here are three of the personnel of the Magcobar Research and Development Center at Arlington Heights, Illinois.

Gerry Morrical, Manager, had five years experience in foundry production prior to joining Magcobar in 1955. Born in Walkerton, Indiana, and an All-America footballer at the University of Indiana, Gerry keeps one eye on industry trends and problems and the other on Magcobar activities, as he tailors Magcobar service for maximum benefits to customers.

Art Zrimsek, Sand Engineer, came to Magcobar five years ago with experience at several midwest foundries. He has a broad knowledge of foundry procedures and bentonite requirements. Born in Milwaukee, he holds B.S. and M.S. degrees in Metallurgy from the University of Wisconsin.

George Vingas, Foundry Research Engineer, has served as a Sand Control Engineer and as a Research Director with firms in the United States and Canada. His education and experience make him particularly qualified to conduct research in sand problems. Born in Alexandria, Egypt, he graduated from Farouk University at Alexandria.

These men are typical of the representatives who go to work for you when you buy bentonites from Magcobar.

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Circle No. 155, Pages 129-130

PITTSBURGH—Newly elected officers—front row: Vice-President Walter E. Mason, Westinghouse Air Brake Corp.; President C. E. Peterson, E. W. Bliss Co.; and Secretary-Treasurer E. P. Buchanan, Pittsburgh Coke & Chemical Co. Back row: Director A. M. Cadman, Cadman Mfg. Co.; Director Wm. D. Hacker, Mesta Machine Co.; and Director J. H. O'Rourke, Jones & Laughlin Steel Corp.—by Walter Napp

TEXAS—Casting defects and their possible solutions were studied recently by a panel. Members were Ross Williams, East Texas Steel Casting Co.; W. P. Bowdry III, Dallas Foundry, Inc.; moderator Harold H. Judson, Alamo Iron Works; J. L. Maenza, Dee Brass Foundry, Inc.; D. M. Keating, Smith Steel Casting Co.; and Irving Tetzlaff.—by C. Eugene Silver

TENNESSEE—Ladies Night Chairman Frank Anderson, left, with speaker Jac Chambliss, Chairman Tom Deakins, and Vice-Chairman Jim Payne. The ladies night was attended by 180 persons.—by J. D. Kling

PHILADELPHIA — Certificates of achievement for educational activities were awarded by Chairman R. C. Stokes, center, to John Gross and Ed Saks, both of Dobbins Vocational High School.—by Leo Houser and Ed Klank

TRI-STATE—Safety and human relations was discussed by E. J. Boywid, International Harvester Co., left. On right is Harry Ferlin, 1960-61 chapter Chairman.—by Bobby Bell

METROPOLITAN—Retiring Chairman J. P. O'Neill, Malcom Foundry Co., right, flashes a suspicious smile, in turning over chapter direction to R. V. Hunter, Archer-Daniels-Midland Co.—by Walter Napp

Northeastern Ohio Chapter

Motivation for Quality

How motivation for quality can be installed in foundries was outlined in a case history by Dr. J. M. Juran, consultant, New York.

First step in the program was to reduce or eliminate the effects of management controlled factors such as improper methods and equipment. The second step was to improve worker performance for better quality.

More specifically, management organized a breakdown of the economics of their defective castings and the problems involved. A priority list of casting problems was developed and the more important ones selected to be studied first.

Next, a steering committee of management personnel was organized. This committee first collected a list of all possible theories as to why the defective castings occurred. Since this committee had the authority to experiment, it proved the action necessary to collect data.

In addition, a diagnostic group was set up to design experiments following the suggested theories, collect the data, and analyze the results. One requirement of the latter group was complete objectivity so that it did not include any operating management personnel. An important point emphasized by the speaker was that neither of these groups could function alone.

An analysis of final results suggested remedies, some of which were of permanent or irreversible nature, whereas others were reversible. The latter remedies required observation periodically to insure that they were working.

When all management controllable factors were taken care of, a campaign was organized to improve worker performance. The campaign consisted of a slogan contest, a general program detailing how quality control helps the worker, pamphlets of information for the workers telling them how they could help improve quality, and a scoreboard showing weekly results of efforts to improve quality. A suggestion system was also maintained.—by Wallace D. Huskonen

Central Illinois Chapter

Shell Molding Process

A statistical method for defining what tolerances can be maintained on any shell molding casting was outlined by C. R. Baker, Albion Malleable Iron Co., Albion, Mich.

The method not only defines capability but provides a qulaity control and gives immediate warning of silicone build-up and pattern wear as well as determining whether or not the job should put into shell molding.—by Charles W. Search

Texas Chapter

Castings Defect Symposium

Common casting defects were studied by a five-man panel with Harold H. Judson, Alamo Iron Works, serving as moderator. Panelists were J. L. Maenza, Dee Brass Foundry; Irving Tetzlaff, Texas Foundries, Inc., Ross Williams, East Texas Steel Castings Co.; W. P. Bowdry III, Dallas Foundry, Inc.; and D. M. Keating, Smith Steel Casting Co.

Through the cooperation of the Northwestern Pennsylvania Chapter, the Texas Chapter purchased 53 color slides showing 64 defects in gray iron, steel, malleable, ductile iron, aluminum, and brass castings. Slides were projected, information read by the moderator on the defects, and panel members called on to name the defect and possible remedies. Two sessions were held on the defects.

Plant visitations were made at Lufkin Foundry & Machine Co. and Texas Foundries, Inc.—by C. Eugene Silver.

San Antonio Section

Close Tolerance Castings

Good pattern equipment is essential in the production of close tolerance castings, pointed out Bill Merkel, K. O. Steel Co. Properly produced, close tolerance castings by the investment casting process require no machining work.

Merkel also discussed ceramic molding and shell molding. Various castings made by the processes were demonstrated.—by Frank Page

Twin City Chapter

Reliable Foundry Costs

A proper selling price is one that covers all the possible costs and brings in a profit, said Jeff Westover, Westover Corp., Milwaukee. He pointed out that reliable costs must be ascertained and used to conduct a profitable business.

Westover pointed out that foundries regardless of size must adopt reliable cost programs. He recommended that the foundry manager set up cost standards for each center of activity, adding that it is not correct to combine labor and material costs. Other topics discussed were break-even charts, overhead items, invoice handling, and maintenance. —by Matt Granlund

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EASTERN CANADA—Winners in the chapter's apprentice contest. Wood patternmaking—R. Baretti, A. McComb, and E. Myers, all of Dominion Engineering Works. Iron molding—L. Cordeau, Ecole des Metiers; C. Rancourt, Montreal School of Technology; and M. Latreille, Dominion Engineering Works. Non-ferrous molding, R. Tourgney and R. Dion both of Ecole des Metiers. Steel Molding, R. Lapreniere, Ecole des Metiers.—by J. C. Cherrett

Dominic Meaglia, left, president, American Foundry, Los Angeles, receives 50-year pin from General Manager Wm. W. Maloney.

MICHIANA—New officers and directors include: Director Jerry Dawson, Josam Foundry; Vice-Chairman Reno Bartolucci, Auto Specialties Co.; Chairman Vernon Compton, LaPorte Foundry; Director Dick Fenska, Wheelabrator Corp.; Director Joe Lazzara, Sibley Machine & Foundry. Director George Truman was absent.—by Joe Lazzara

WESTERN MICHIGAN—Richard Williams, Wyant & Cannon Foundry Co., left, new Chapter Chairman, takes over from retiring Chairman W. A. Blackmer, Muskegon Piston Ring Co. —by J. L. Brooks

NEW ENGLAND—Shell molding and shell cores were explained recently by L. E. Wile, Lynchburg Foundry Co., second from left. Others are H. H. Klein, P. C. Smith, and Lewis Greenslade.—by J. H. Orrok

WISCONSIN—E. Gritzmacher, Universal Foundry, displays his old-timers plaque awarded by the chapter. In the background is R. Osborne, Lakeside Malleable Co.—by Bob DeBroux

MICHIANA—Herbert Von Wolff, National Acme Co., discusses his subject for the evening, Shell Cores and New Trends with Vice-Chairman Vernon Compton and Chairman Walt Ostrowski.—by Joe Lazzara

EASTERN CANADA—Winners of the chapter's technical paper writing contest are T. Finlay, R. Filtrin, B. Gladu and C. Coutu.—by J. C. Cherrett

BRITISH COLUMBIA—Chairman Henry Bromley, right, congratulates Wayne Belanger, national first-place winner in the AFS Apprentice Contest.—by J. G. Smith

CONNECTICUT—About 200 persons attended the special night held jointly with the Connecticut Non-Ferrous Foundrymen's Association. The general committee was headed by AFS National Director R. R. Ashley. Mrs. Ashley, Mrs. Oswin Warner and Mrs. Kenneth Jones headed the ladies committee. Shown are Mrs. Sarah Warner, Mrs. Audrey Ashley, and Mrs. Constance Jones—by Steve LeRoy

WISCONSIN—Care and use crucible and furnace refractory materials were explained by C. B. Murton, Vesuvius Crucible Co., left. On right S. MacNeill, Ajax Magnethermic Co.—by Bob DeBroux

TWIN CITY—There's no gavel shortage in the Twin City area. Incoming Chairman Frank Ryan, left, St. Paul Brass Foundry, and retiring Chairman Harry Blumenthal, Harry Blumenthal Co., exchange at a recent meeting. —by Matt Granlund

CHICAGO—Incoming Chapter Chairman Robert C. Johnson, Hickman, Williams & Co., left, congratulates retiring Chapter Chairman Don Meeves, who holds the cast award presented to former chairmen.—by George DiSylvestro

Future Meetings and Exhibits

Sept. 21-22 . . Missouri Valley Regional Conference, Rolla School of Mines, Rolla, Missouri.

Sept. 22-23 . . East Coast Regional Foundry Conference, Statler-Hilton Hotel, New York.

Sept. 24-26 . . Steel Founders' Society of America, Fall Meeting. The Homestead, Hot Springs, Va.

Oct. 5-6 . . Ohio Regional Conference. Netherland Hilton Hotel, Cincinnati.

Oct. 13-14 . . New England Foundry Conference, Massachusetts Institute of Technology, Cambridge, Mass.

Oct. 18-20 . . Gray Iron Founders' Society, Annual Meeting. Royal York Hotel, Toronto, Ont.

Oct. 19-20 . . Michigan Regional Foundry Conference. Michigan State University, East Lansing, Mich.

Oct. 19-21 . . Foundry Equipment Manufacturers Assn., Annual Meeting. The Greenbrier, White Sulphur Springs, W. Va.

Oct. 23-27 . . American Society for Metals, Detroit Metal Show (43rd National Metal Congress and Exposition), Cobo Hall, Detroit, Mich.

Oct. 26-27 . . Purdue Metals Castings Conference, Purdue University, Lafayette, Ind.

Nov. 13-15 . . Steel Founders' Society of America, Technical & Operating Conference. Pick Carter Hotel, Cleveland.

Nov. 15-17 . . National Foundry Association, Annual Meeting. Savory-Hilton Hotel, New York.

AFS Chapter Meetings

Canton District . . Aug. 5 . . *Annual Picnic & Golf Outing,* Brookside Country Club, Barberton, Ohio.

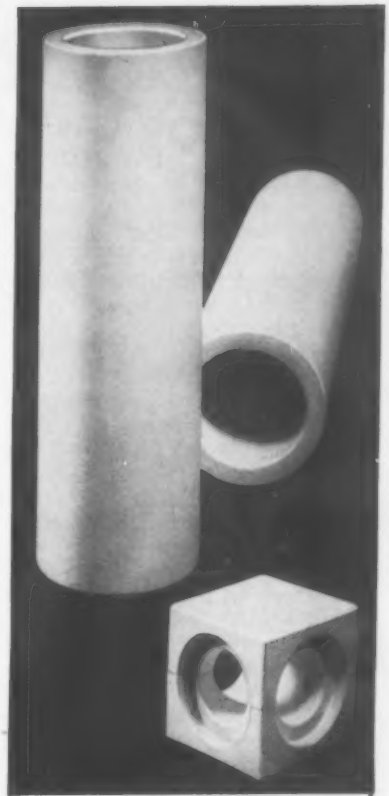
Central Ohio . . July 14 . . *Board of Directors Meeting . .* Maennechor, Columbus, Ohio.

Philadelphia . . July 14 . . *Annual Outing & Picnic,* Manufacturers' Country Club, Oreland, Pa.

St. Louis . . Aug. 9 . . *Picnic,* Shady Acres Grove, St. Louis, Mo.

Twin City . . Aug. 14 . . *Summer Golf Party,* Midland Hills Country Club, St. Paul, Minn.

Wisconsin . . July 21 . . *Annual Outing,* Golf Bowl, Milwaukee.



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Circle No. 116, Pages 129-130

Foundry Trade News

Frank Foundries . . . Davenport, Iowa, has furnished to the National Bureau of Standards special alloyed gray iron castings for its analytical standards. Within the past two years the company has been asked by the Bureau to furnish three different alloyed cast iron standards.

Massey Gin & Machine Works . . . foundry building at Macon, Ga., has been demolished and the 325 acre tract on which it was located will become an industrial site. The foundry was built a few years after the original building, used to manufacture parts for Confederate rifles, was burned. Members of the Massey family had operated the gin and machine shop from 1846 until it went out of business in 1957. The old Massey Works manufactured "Joe Brown" pikes, a bayonet named after Georgia's Civil War governor, and also turned out syrup kettles, special castings, and other metal products.

A. Finkl & Sons . . . Chicago, has developed two refinements to its vacuum degassing of molten steel in the ladle. One is the pouring of vacuum degasses steel through a blanket of argon gas and into ingot molds filled with argon. The second is the development of a method to put additives in the molten steel while the ladle is under a high vacuum inside the vacuum degassing chamber. Perfection of these refinements allows the production of all aircraft quality alloy steels with these new methods.

Stauffer Chemical Co. . . . New York, has licensed National Research Corp., Cambridge, Mass., to operate electron beam melting and casting furnaces under a Stauffer patent.

Gale Mfg. Co. . . . Albion, Mich., has formed a new manufacturing division of the corporation, to be known as the Alumicast Division. Operations will include the casting of aluminum by the sand, permanent mold, and shell casting processes. The initial melting capacity of the operation will be 9600 lb. of aluminum per day with future plans for expansion.

Ajax Magnethermic Corp. . . . Youngstown, Ohio announces a joint acquisition of the Safety Electrical Equipment Corporation of New Haven, Conn. The company has purchased 50% of the stock and the other 50% has been purchased by a group headed by R. Dodds.

American Steel Foundries . . . reported sales and earnings for the quarter ended March 1961 were down as compared with a year ago. The depressed condition of the over-all economy resulted in a decreased demand for most of the major product lines. The company also announced license agreements with Washington Steel Corp., and Michigan Seamless Tube Co., for their use of ASF's controlled pressure pouring process to produce semi-finished steel mill shapes, such as blooms, slabs, billets and tube rounds, by pouring molten steel directly into semi-permanent reaphite molds.

Lava Crucible-Refractories Co. . . . appointed Eastern Crucible Refractories Co., as its exclusive sales representative for the eastern United States.

Sivyer Steel Casting Co. . . . has purchased Riverside Foundry Co., Bettendorf, Iowa. The new facilities will be operated as the Riverside Div., with President R. H. Swartz becoming a Sivyer vice-president.

Cleveland Standard Pattern Works . . . Cleveland, has issued a statement on its company personnel. John F. Roth continues as president and general manager, and Walter H. Siebert as vice-president and production manager. In October, 1960, Carl Winkler retired and disposed of all interests in the corporation. Roth, an associate of the company for 32 years, assumed the position of presidency, purchasing Winkler's stock. Shortly later, Siebert, then production manager and also associated with the company for many years, acquired a substantial stock interest in the corporation.

Canadian Steel Foundries, Ltd. . . . has started production on the 12 largest steel castings ever made in Canada. The castings representing a million dollar order, will be used to make rolling mills. Each will be 32 ft long, 14 ft wide, 38 in. thick, and weigh 30,000 lb. The first pour was made at the company's Montreal East plant in April. Some 500,000 lb of steel at 2800 F. were poured from four ladles in three minutes—the first quadruple pour in Canada. Two ladles were transported half a mile from the neighboring plant of Canadian Steel Wheel, Ltd. A third heat was produced by Canadian Steel Foundries with their electric furnace. An oil-fired open hearth furnace at the foundry was brought into production to provide an additional 50-ton heat of steel.

Wellman Bronze & Aluminum Co. . . . has moved its plant facilities from Cleveland to the former Dow Metal Products Co. magnesium and aluminum casting plant in Bay City, Mich. Wellman leased the foundry from Dow Chemical in February of this year. The Bay City facilities make Wellman the largest U. S. foundry for sand and permanent mold magnesium and aluminum castings. Major expansion will be made in the aluminum castings area. When completed, the foundry will have 25 aluminum and six magnesium permanent molding units.

American Society for Testing Materials . . . Philadelphia, has available for sale a packaged system of code-punched cards with current high-temperature strength data of metals and alloys. The cards are collected and compiled by the A.S.T.M.-A.S.M.E. committee on the effect of temperature and properties of metals.

Olin Mathieson Chemical Corp. . . . is replacing the 45-year-old Western Brass name with Olin Brass. The trade name is being changed in the interests of simplicity, uniformity, and closer identification with Olin Mathieson Chemical Corp.

WaiMet Alloys Co. . . . Div. Howe Sound Co., now offers vacuum-melted metals to customer specification. Vacuum metal facilities include 2000 and 4000-lb vacuum melting furnaces having a capacity of 5 to 6 million lb per year, as well as forming and vacuum casting equipment to fabricate alloys into various shapes and forms.

Associated Foundry Services, Inc. . . . Los Angeles, has named three distributors. Snyder Foundry Supply Co., Los Angeles, will cover southern California, Arizona, and New Mexico. Amador Minerals, Sacramento, Calif., will handle the northern California territory; and DeFreece Precision Casting Specialties, Bellevue, Wash., will handle Washington, Oregon, and British Columbia.

Gulf Coast Foundry . . . has started operations at Foley, Ala. It manufactures iron and aluminum furniture, industrial, and construction items.

Let's Get Personal . . .

A. J. Moore . . . has been named as president, Canadian Bronze Co., Ltd., Montreal, Canada. He has been a resident of Montreal since 1941 when he joined Montreal Bronze, Ltd., as superintendent, later becoming district manager. He joined Vanadium Alloys, Ltd., in 1956 as eastern manager and in 1956 became executive vice-president of Canadian Bronze Co., Ltd. Moore has been an AFS Director since 1959 and during 1960-61 served as an AFS Regional Vice-President.

A. J. Moore

Ralph E. Koch . . . is sales representative in northeastern Ohio for Miller Refractories Co., Cleveland.

Edward H. Richard . . . has been appointed sales manager for the Ohio Electric Mfg. Co., Cleveland.

Dr. James L. Wyatt . . . named vice-president for program development at the Armour Research Foundation of Illinois Institute of Technology, Chicago. Wyatt will plan and coordinate all promotional activities for government and industrial research and will assist in the planning and development of new research.

R. C. Marthens Co. . . . Moline, Ill., named sales representative for Werner G. Smith, Inc.

W. R. Ramsay . . . elected 1st vice-president, North American Refractories Co., Cleveland. **E. A. Williams, Jr.**, voted vice-president, operations, and **Frederic W. Schroeder** was choosen vice-president, charge of research.

Thomas Welfer . . . is secretary, Harbison-Walker Refractories Co., Pittsburgh, Pa.

Arthur G. Byrne, Inc. . . . is sales representatives for the Newton-New Haven Company, covering the Brooklyn and Long Island Area.

Samuel C. Clark . . . named to the board of directors, Chambersburg Engineering Co., succeeding **Harrie B. Price Jr.**, who retired after 30 years as a director. **Robert W. Young** is purchasing agent succeeding **W. Hastie Derbyshire**, who retired.

Richard S. Moyer . . . appointed director of manufacturing for Link-Belt Co., Chicago.

Roger J. Brown . . . is district manager, Frederic B. Stevens, Inc., Detroit, and will headquarter in Buffalo, N. Y.

P. C. Mitchell and J. C. Willey . . . have been elected to the Board of Directors for Harbison-Walker, Pittsburgh, Pa.

Mrs. Evelyn C. Heinzelman . . . elected chairman of the board, Palmyra basic Foundry Inc., Palmyra, Wis. Mrs. Heinzelman was previously president.

Mark M. Miller . . . has joined Texas Foundries, Inc., Lufkin, Texas as general manager in charge of domestic and international sales for the malleable, steel, ductile, and machining divisions.

Donald F. Kittredge . . . is assistant vice-president, International Div., National Castings Co., Cleveland.

Stanley M. Hunt . . . is responsible for marketing development in a new district sales office for Acheson Colloids Co.; Port Huron, Michigan. This new office in Hartford, Conn. will serve the New England states.

Jack Parmenter . . . Park Ridge, Ill., has been appointed technical sales representative, greater Chicago area, for Foseco, Inc., Cleveland. He will cover central and southern Illinois and southeastern Iowa.

Stanley V. Lucas . . . is responsible for U.S. Steel, American Steel & Wire Div., pig iron sales in northwestern Ohio, Michigan and Indiana. **C. W. Haas** will cover the eastern half of Pennsylvania, the eastern portion of southern New York, the states of Maryland and Virginia, and all of the New England states. **T. D. Brown,** has been assigned to the lower portion of Wisconsin, the state of Iowa, and the upper portion of Illinois.

Clarence C. Hanson . . . has been elevated to vice-president and general manager, Trenton, N. J. division, Ajax Magnethermic Corp., Youngstown, Ohio. He will be in charge of the induction melting equipment division of Ajax. **James K. McLaughlin** has been advanced to vice-president in charge of the Youngstown division and will coordinate activities at the Youngstown induction heating division.

Kenneth S Wayman . . . has been promoted to quality control manager, Dow Metal Products Co., Div. Dow Chemical Co., Madison, Ill. **Frederick P. Streiter,** is laboratory division leader at Madison, Ill. **Gordon F. Hershey** is now chief inspector and **James R. Widmoyer** is now assistant to Streiter on rolling ingot casting problems.

Anthony Haswell . . . elected as chairman of the board, Dayton Malleable Iron Co. **John F. Torley** named as president and general manager.

obituaries

C. W. Boettcher, vice-president in charge of sales. He was formerly sales manager, Flask Div., Black, Sivalls & Bryson Co., Kansas City, Mo., for 15 years and continued this position with the new owners, American Foundry Flask Co., for five years.

Frank Thomas Hamilton, in Gadsen, Ala. He was president of Rudisill Foundry in Anniston and a past president of Cast Iron Soil Pipe Institute.

Vernon S. Spears, blast cleaning specialist in the U.S. central region for Wheelabrator Corp. He was a member of the sales department of Wheelabrator for more than 25 years and had been chairman of the AFS Michiana Chapter.

Leonard Geiser, president Cincinnati Steel Castings Co., Cincinnati.

George H. Ralls, 69, president and general manager, Pressure Castings Co., Cleveland.

Charles J. Nock, Sr., 62, president, Nock & Son Co., Cleveland. He had been active in the refractory business for over 40 years. More than 30 years were spent with Nock Fire Brick Co., founded by his father. In 1947 he organized Nock & Son to manufacture refractory specialties. He was a member of AFS and other technical societies.

New Products and Processes

What's new in foundry methods and equipment? Summaries of many are presented below. Circle corresponding number on free postcard, page 129. Mail it to us; we'll do the rest.

Shell Investment Furnace Handles Casting Molds of all Sizes

Shell investment mold furnace features ease of installation in small working areas and operator convenience. Gas-fired furnace can be used for firing all shell investment casting molds. Mechanism is built close to furnace side-wall to avoid protrusion of parts into adjacent working area. Counterweighted drop-bottom trapdoors are hinged from sides of furnace to facilitate easy front opening and closing. Alexander Saunders & Co.

Circle No. 1, Pages 129-130

Adjustable Conveyor Bracket Cuts Spillage and Wandering

Adjustable conveyor bracket reportedly cuts spillage and increases capacity of conveyor by 26 per cent without expensive belt construction or disadvantages of steel rolls at steep angles. Bracket can be adjusted from 20 to 45 degrees with belt height remaining the same. Said to prevent spillage and wandering belts due to off-center loads through adjustability to keep deep troughs at loading points. Florida Conveyor & Equipment Co.

Circle No. 2, Pages 129-130

Resin Hardener Combination Coats Warm and Hot Sands

Resin-hardener combination produces both hot and warm coated sand for shell molds and cores. The phenolic resin is waterborne and nonflammable. The combination can be processed in a variety of sand mullers with hot air supply and can also be used with preheated sand. Surface finish of castings is excellent. Strength and resistance to thermal shock of shell molds made with the combination yields a high degree of dimensional stability and tolerance control. Dwell and curing times of shell molds and cores are short and suitable for high production work. Union Carbide Plastics Co., Div. Union Carbide Corp.

Circle No. 3, Pages 129-130

Design Die Casting Lubricants For Aluminum, Magnesium, Zinc

Die casting lubricants reportedly offer unlimited storage stability, uniformity of product, and stability to repeated freeze-thaw cycles, and ease of cleaning. Due to new formulation, lubricants are said to eliminate problems during finishing operations; are equally effective for casting of aluminum, magnesium, and zinc; are available for either solvent or water dilution; and are completely ashless and non-cokeforming. Chem-Trend.

Circle No. 4, Pages 129-130

Insulating Fire Brick Line Covers Temperatures to 2900 F.

Insulating fire brick line covers exposed service temperatures from 1600 F. to 2900 F. New line consists of six types. Because of their light weight less steel work is required for supporting walls, arches, and foundations. Available in a variety of sizes and shapes, are virtually sulphur free and meet both A.S.T.M. and military specifications for insulating refractories. Kaiser Refractories & Chemicals Div., Kaiser Aluminum & Chemical Corp.

Circle No. 5, Pages 129-130

Compact Tensile Testing Unit Features Easy Adaptability

Compact tensile testing machines have capacities up to 40,000 lb with over-all height of only 72 inches. Stroke of tensile testers is only 4 inches, and specimens up to 10 inches long by 2 inches wide can be accommodated. To compensate for various specimen lengths, lower jaw holder can be inserted into any of three pairs of slots in the side rails. Different size and style jaws can be easily inserted or removed. Steel City Testing Machines, Inc.

Circle No. 6, Pages 129-130

Controlled-Weight Foundry Pigs Produced To Meet Growing Demand

A new closely-controlled-weight foundry pig, supplementing the 10-pound pig, is being produced by the company specifically for gray and malleable iron foundries. Firm announces that its automatic casting system has been equipped with special weighing and selector device that permits closer control of the weight of the iron-manganese alloy pigs and assures an average of 2 pounds of manganese per pig. A supply of the new pigs is now available for shipment. New Jersey Zinc Co.

Circle No. 7, Pages 129-130

Unit Designed For Low Cost Breakage of Cast Iron, Scrap

Two basic models of a device that offers low cost breakage of cast iron, rail scrap, etc., have been developed. The standard unit utilizes the buyer's own crane and magnet for power; the integrated unit contains its own lifting device and magnet. Both will deliver an impact of over 3 million lb per square inch, and will break cast iron over 6 inches thick. Select Enterprises, Inc.

Circle No. 8, Pages 129-130

Automatic Unit Molds For Thin-Walled Castings

A new automatic molding machine capable of high-speed production of uniform, high-density green sand molds for thin-walled castings has been introduced. Unit produces precision molds in production volume by compressing the sand by a hydraulic ram and a pneumatic compensating pad. It has consistently produced molds up to 45 inches deep with uniform mold hardness between 95 and 100 (Dietert). Taccone Corp.

Circle No. 9, Pages 129-130

Alloy Broadens Use Of Aluminum Castings

New aluminum alloy is high strength, shock resistant, developed for use where higher yield strengths and lower elongation are required. In the condition as-cast and aged at room temperature, it develops a

high combination of physical and mechanical properties with extremely high yield strengths, for applications where shock loads are superimposed on top of high static loading. William Jobbins, Inc.

Circle No. 10, Pages 129-130

Sand Coating Machine Is Self-Contained Unit

A compact, fully automatic shell sand coating plant, is mounted on a heavy steel bed, fully wired and piped. The unit only requires connection of air lines and electric power to the control panel to be operational. Features include a built-in pneumatic skip-hoist; electrically heated air flow; resin dispenser and injector; and optional warm or hot process. Shalco Div., National Acme Co.

Circle No. 11, Pages 129-130

Testing Concentrates Allow Easier Mixing, Handling

A completely new family of materials for the wet method of visible and fluorescent magnetic particle testing is being introduced. They are a result of continual research of a proven test method and magnetic particles pastes used to locate invisible cracks in ferrous material and parts. The new materials are all in powder form. Magnaflux Corp.

Circle No. 12, Pages 129-130

Unit Can Handle Core Boxes Up to 30 Inches High

A completely automatic hollow shell core machine, with both pneumatic and electric controls, has a direct gas fired manifold with 210,000 Btu output. The sand magazine, of 150 lb capacity, travels on a specially constructed track and is clamped by a pneumatic-powered latch. Unit is also equipped with a 300 lb shell sand storage hopper with automatic feeding unit. Beardsley & Piper Div., Pettibone Mulliken Corp.

Circle No. 13, Pages 129-130

Process Simplifies Resin-Coating Procedures

A new process for coating sand particles with a thermosetting phenolic resin increases simplicity and efficiency of producing shell molds and cores made of sand particles tightly bonded by resins. It permits use of either powdered phenolic resins or resin solutions for sand-coating purposes. The entire coating process can be conducted cold or accelerated with hot air. Standard and readily available equipment may be used to produce the coated sand. The company recommends the use of sharp-grained sand possessing low fineness and clay content be used with its patented process. Durez Plastics Div., Hooker Chemical Corp.

Circle No. 14, Pages 129-130

Dry Materials Collection Unit Uses Moisture for Control

Dust free handling of dry materials is possible for continuous-flow bulk materials. Unit makes it possible to manage powdery, finely-divided materials such as sinter fines from collection equipment. Process uses precisely controlled amount of moisture into finely-divided material for suppression. Key to effective conditioning is wetting of surfaces by powerful surface active compound. Wetting adds as little as 1 per cent moisture or may be adjusted to any desired amount. Available in three models handling between 150 lb to 150 tons hourly. Johnson-March Corp.

Circle No. 15, Pages 129-130

NBS Develops New Spectroscopic Samples

Two new types of spectochemical standards—a set of eight white cast-irons and a set of three naval brasses—have been developed and made available by the National Bureau of Standards. These standards are suitable for both optical emission and x-ray analysis. As part of the Bureau's program, spectroscopic standard samples are prepared, chemically analyzed and certified in close cooperation with industrial and government groups. Standard Samples Clerk, National Bureau of Standards, Washington 25, D. C.

Circle No. 16, Pages 129-130

Air-Operated Lifting Arm Features Speed and Control

Air-operated lifting arm features vertical speed which can be varied from 12 to 400 feet per minute using finger tip control. Unit, which lifts up to 200 lb, is controlled by following hand movements. Lift has only one adjustment that allows it to maintain any height when operating hand is in neutral. It may be adjusted to any height either with or without a load. Servo Lift Co.

Circle No. 17, Pages 129-130

Unit Extrudes Refractory Materials In Uniform Column

A new, improved machine for the placement of refractory castables is now available which extrudes refractory materials in a uniform column under pressure from a sealed mixing chamber to the area of application. The machine provides for greater mobility and ease of loading. The charging door at the front of the unit has been lowered to facilitate loading bagged material into the machine, and the motor has been moved to a lower position. Kaiser Refractories & Chemicals Division.

Circle No. 18, Pages 129-130

Safety Binders . . . . with modern castings

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For The Asking

Build an idea file for improvement and profit.
Circle numbers on literature request card, page 129, for manufacturers' publications.

Carbon sand . . . a fluid coke which has been calcined at 2500 degrees F. is described in information sheets now available. Among advantages cited are savings in cleaning time, accuracy and improved appearance of castings, and less scrap. Product shows exceptional thermal stability. Humble Oil & Refining Co.

Circle No. 25, Pages 129-130

Die casting machine . . . information on two new developments on company's locking pressure die casting machine is available. A new hydraulic combination pump delivers 21.8 gallons per minute, doubling previous output of die castings, and the safety shot die interlock has been re-designed for greater safety. American Die Casting Machinery Co.

Circle No. 26, Pages 129-130

Magnetic inspection system . . . featuring a variable voltage control, is described in brochure. Portable, nondestructive system can obtain information on weld penetration, missing welds, weld spacing, in addition to inspecting cold, worked stainless steels and precipitation hardening grades of stainless steel. Instruments Div., Budd Co.

Circle No. 27, Pages 129-130

Buried blast burners . . . for sealed or tight combustion chamber applications such as ceramic firing, process heating, ferrous and nonferrous metal-melting or heat-treating, billet heating, and other processes. Nine burner sizes are listed in a choice of 54 maximum firing capacities from 60,000 to 14,500,000 Btu/hr. Eclipse Fuel Engineering Co.

Circle No. 28, Pages 129-130

High pressure hydraulic die casting machine . . . available either as hot chamber for casting zinc, lead or tin alloys, or as cold chamber machine for casting aluminum, brass or magnesium alloys, is explained in six-page bulletin. Model has a strain gage tested locking pressure of 400 tons. Illustrated bulletin provides essential details. Cleveland Automatic Machine Co.

Circle No. 29, Pages 129-130

Pre-casting treatments . . . brochure lists products for treatment of copper and nickel alloys before casting. Names and describes properties of each compound, discusses problems solved by applications, and lists advantages of each metal treatment. Detailed text explains covering and cleaning fluxes, degassers, deoxidants, exothermics, and other metallurgical aids compounded especially for treating copper and nickel alloys. Foundry Services, Inc.

Circle No. 30, Pages 129-130

Periclase chrome basic brick . . . containing approximately 71% magnesia, and chemically bonded, is depicted in bulletin. Also described is a burned periclase chrome basic brick containing approximately 73% magnesia. Both types are furnished plain or cladded with steel plates. Used where high magnesite chrome compositions are indicated. H. K. Porter Co., Inc., Refractories Div.

Circle No. 31, Pages 129-130

Riser sleeves . . . constructed of permeable plaster, are available in two and three-foot lengths, with inside diameters ranging from 1-1/2 to 12 inches. Suitable for use when casting magnesium, aluminum, brass and bronze. Doubles riser efficiency. Long lengths may be easily cut to desired height. Dalton Co.

Circle No. 32, Pages 129-130

Centrifugal dust separator . . . bulletin, 12 pages, includes performance data, selection and dimension charts, and installation photos. The model is a high efficiency unit in 20 standard sizes which can handle air volumes from 150 cfm and up. Multiple groupings can be furnished to meet any collection requirements. Day Co.

Circle No. 33, Pages 129-130

Rare earth uses . . . are cataloged in 8-page folder which lists compounds, grades, appearance, properties, typical chemical analysis, and suggested end uses. New techniques of separation are responsible for the rapid growth and use of these elements. Vitro Chemical Co.

Circle No. 34, Pages 129-130

Facilities for design . . . and production of aluminum, zinc die castings described in illustrated brochure, including photographs of plant operations, production, engineering, sales and administrative personnel, plus information on the history of the company. Newton-New Haven Co.

Circle No. 35, Pages 129-130

Most frequently used chaplets . . . are illustrated and described in a large wall chart, designed to simplify specifying and ordering. It offers complete sizing information on each of the many chaplets, including motor, button head, radiator, double head, single head, perforated, etc. Fanner Mfg. Co.

Circle No. 36, Pages 129-130

Emulsion type cleaner . . . data sheet depicts metal cleaner that also leaves a film that protects parts from rusting during processing or in storing. Information on how to use the material is also included. E. F. Houghton & Co.

Circle No. 37, Pages 129-130

"Advantages of ladle additions of exothermic ferochromium," . . . a paper, has been made available, discussing how chromium content in steel can be adjusted in the ladle by adding exothermic ferrochromium, which disperses the alloying agent throughout the melt. Vanadium Corp. of America.

Circle No. 38, Pages 129-130

Electric ovens, furnaces . . . new, 240-page catalog illustrates firm's complete line of electric ovens, furnaces, baths, environmental cabinets, related temperature control equipment and accessories for laboratory, pilot plant and production. Blue M Electric Co.

Circle No. 39, Pages 129-130

New foundry resin . . . literature offers information on a resin, developed for cold-coating sand, which helps yield a fast curing sand suitable for

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producing both shell molds and cores. Material is recommended for use where a short to medium flow, fast curing resin is required, and for application in which freedom from shell warpage is difficult to achieve. Union Carbide Plastic Co., Div. of Union Carbide Corp.

Circle No. 40, Pages 129-130

Front end loaders . . . the many applications that can be handled by these units are explained in a new booklet, which covers each of the three wheel-type and three track-type machines. Each unit is shown under working conditions. Caterpillar Tractor Co.

Circle No. 41, Pages 129-130

Power sweeper . . . illustrated bulletin shows operation of a recently developed heavy duty sweeper, Unit sweeps a 53 in. path (including side brush), picks up both heavy litter and fine dust in one operation. G. H. Tennant Co.

Circle No. 42, Pages 129-130

Research and development . . . a descriptive statement, "The Administrative Controls of Contract Research for Industry," is being offered to representatives of industry concerned with research and development. The statement describes the balance of administrative controls between the sponsor of a project and the research institute engaged, under contract, to conduct the study. Battelle Memorial Institute.

Circle No. 43, Pages 129-130

Heat exchanger . . . an 8-page illustrated catalog describes firm's new impervious graphite counterflow block heat exchanger. The simple block construction that makes possible a range of heat transfer capacity is described, and the five different flow arrangements using single, three and five passes are shown. National Carbon Co.; Div. Union Carbide Corp.

Circle No. 44, Pages 129-130

Temperature indicating paints . . . are described in booklet. Materials will change their original color when certain temperatures are reached. These changes are not merely slight alterations in shades of original color, but a distinct change to a completely different color. Princeton Div., Curtiss-Wright Corp.

Circle No. 45, Pages 129-130

Patching, ramming mix . . . folder gives data on a new, improved formulation, a basic patching and ramming mix. Included is information on cold-crushing strengths, product analysis, physical and chemical composition, and a brief description of installation methods. Kaiser Refractories & Chemicals Div.

Circle No. 46, Pages 129-130

Design and plant engineering . . . site selection and development, consultation-management, are sections covered in this brochure of consulting services. Lester B. Knight & Associates.

Circle No. 47, Pages 129-130

Aluminum furnace refractories . . . each developed for a specific operating condition, are explained in 8-page reprint. Specific types are recommended for each furnace section enumerated. Harbison-Walker Refractories Co.

Circle No. 48, Pages 129-130

Abrasive selection . . . for blast cleaning can mean the difference between profit and loss. Four-page reprint lists four prime factors to consider in choosing an abrasive for various industrial applications. National Metal Abrasive Co.

Circle No. 49, Pages 129-130

BUILT BETTER FOR BETTER MELTING

HAUSFELD CUSTOMER APPROVED FURNACES

Aluminum Melting and Holding Furnaces
"Ladle Out" Crucible Type for Die Casting, Permanent Mold, or Sand Casting

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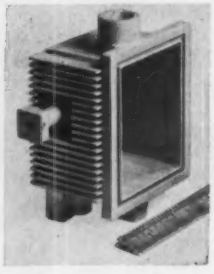

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Saunders Investment Casting Materials help you make Precise Investment Castings. Intricate parts with cores, under-cut sections, etc., can be cast in one piece at one time! Production can be increased, tolerances held closely with fine surface finish.

Sherwood Wax Injection Presses work at lower temperatures to give precise pattern production — Saunders "Blue Wax" has high tensile strength, hard surface and low ash content to give castings a better surface finish and reliable adherence to tolerance. High Quality Refractory Materials offered for shell or monolithic molds. Complete plant set-up for precision investment casting available including Ovens, Fluidized Beds, Turntable Mixers and melting equipment.

Write for Information today,
— latest bulletins or complete catalog.

Alexander Saunders & CO., INC.
95 Bedford Street, New York 14, N. Y.

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New Books

Russian Castings Production . . . British Cast Iron Research Association, Bordesley Hall, Alvechurch, Birmingham, England. A cover-to-cover translation of the Russian foundry journal "Liteinoe Proizvodstvo", the leading Russian monthly for foundrymen. All aspects of castings production are covered, from raw materials through melting processes and equipment, molding sands and methods, casting and shakeout, to service life. While emphasis is placed on cast iron—including gray, white, malleable, nodular and alloy—and steel, there are also articles dealing with non-ferrous, and particularly, light alloy castings. Apart from the specific technical information, a study of the Russian casting production will enable the reader to build a picture of the general development of the Russian foundry industry. The first edition appeared in May, 1961, a translation of the January, 1961 issue.

Metals Handbook . . . 8th edition, Vol. 1, Properties and Selection of Metals. 1300 pages. American Society for Metals, Metals Park (Novelty), Ohio. Contains more information and provides much broader coverage on selection and properties of cast metals than any previous edition. More than 200 pages deal with cast metals and alloys and include 250 tables and 1600 illustrations. The entire volume is devoted exclusively to selection and properties of metals.

Engineered Castings . . . Glenn J. Cook, manager-marketing, Foundry Dept., General Electric Co., 240 pages, McGraw-Hill, 1961. A comprehensive guide for the user and buyer of castings. Primary emphasis is given to casting use rather than casting production and provides a broad understanding of and appreciation for metal castings as engineering materials. Among topics covered are sand molding, shell molding, investment casting, die castings, inspection and testing, vacuum casting, materials, casting designs and tolerance, and foundry selection. Also contains review questions for each chapter, an extensive bibliography on specialized foundry topics and tables of physical properties, tolerances, and specific do's and don'ts of casting design.

The Campbell-Hausfeld Co., producers of metal melting furnaces, should have been listed in the June "Directory of Suppliers" along with the other key suppliers in the metal-casting field.

Classified Advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 35c per word, 30 words minimum, prepaid. **Positions Wanted** . . 10c per word, 30 words minimum, prepaid. Box number, care of **Modern Castings,** counts as 10 words. **Display Classified** . . Based on per-column width, per inch . . 1-time, $22.00 6-time, $20.00 per insertion; 12-time, $18.00 per insertion; prepaid.

HELP WANTED

SALES ENGINEER

Experienced in selling quality castings for newly modernized Foundry. Knowledge of Foundry operations and processes essential. We are moving ahead and need good men. Foundry is only one of company's divisions. If you have "get up and go", send resume! Replies held Confidential. **Box G-105 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

Large Midwestern Brass Manufacturer requires **GENERAL BRASS FOUNDRY FOREMAN.** State experience, education, qualification and salary requirement. **Reply C/O Box G-107 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SALES REPRESENTATIVES—A progressive Michigan Investment Casting Foundry wishes sales representatives for Ohio, Indiana, Illinois and Wisconsin. Prefer sales engineers now selling a line of sand castings. **Reply Box G-106 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY CHEMIST WANTED

Leading supplier to the foundry field has outstanding opportunity for male Foundry Chemist capable of formulation in the field of fluxes and exothermic materials. Must have manufacturing know-how. Send complete resume to: **Box G-104 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

JR. FOUNDRY METALLURGIST
$7,200 to $8,400

Promotable type young man to join rapidly expanding organization that places a great deal of emphasis in engineering proficiency. Client assumes all expenses. Contact Robert L. Moore in confidence.

MONARCH PERSONNEL
28 East Jackson Blvd. Chicago 4 Illinois

MIDWEST MALLEABLE NEEDS

Foundry Metallurgist

Metallurgical degree, will assume responsibility of melting, heat treating, laboratory and sand control.

Chief Inspector and Quality Control

To take full charge of Inspection Department and set up quality control program.

General Molding Foreman

Experienced in gating and risering, efficiency costs, to take full charge of 120 employee department. Reply: **Box G-108 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRYMEN

when you need SUPERVISORY or TECHNICAL men why not consult a man with actual foundry experience plus 15 years in finding and placing FOUNDRY PERSONNEL.

Or if you are a FOUNDRYMAN looking for a new position you will want the advantages of this experience and close contact with employers throughout the country.

For action contact: John Cope
DRAKE PERSONNEL, INC.
29 E. Madison St., Chicago 2, Illinois
Financial 6-8700

SALES—METALLURGICAL PRODUCTS

SALES ENGINEER with technical background, willing to travel. Well established products in steel foundry and heat treating fields. Send resume and salary requirements. **Box G-102 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOR SALE

ONE USED #3 UNIT DRIVE SIMPSON MULLER. Good condition. **Box B-107 S, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

AMERICAN MODEL "AA" SANDCUTTER—4' 8"—No. 906 Can be inspected in operation. Any reasonable offer accepted. **Phone GLENDALE 6-2038—THAYER-PARADINE CORP., 1014 West 12th Street, Erie, Pa.**

Detroit Rocking Indirect Arc Electric Furnace Type LFC, 125 KW, Capacity 350 lbs. cold scrap, 500 lbs. of molten metal. Two shells, complete with automatic electrode control, main control panel and power transformers for 12,000 volt primary power supply. All equipment used very little and in excellent condition. Immediately available. Make offer to: **Box B-111 S, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

QUALITY EQUIPMENT
SAVE AT LEAST 50%

SIMPSON #3, U.D. Muller, 30 cu ft.
B & P Motive Speedslinger
10' Top Charge Mltg. Furnace
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Lip Pour Ladle, 29" dia. x 29" H

700 KW AJAX Induction Mltg. Unit comp. w/6-500# fces, 1000 Hp M.G. set, control panels, trans., cir. breakers. LATEST TYPE—LIKE NEW. 2 tph—send for complete details.

Your dependable dealer for all foundry equip't.

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TUMBLAST WHEELABRATOR — 36x42 — Serial No. A-13364 Can be inspected in operation. Any reasonable offer accepted. **Phone GLENDALE 6-2038 — THAYER-PARADINE CORP., 1014 West 12th Street, Erie, Pennsylvania.**

ENGINEERING SERVICES

FOUNDRY CONSULTANT — NON-FERROUS Sand casting — permanent mold casting — centrifugal casting — in aluminum — brasses — bronzes — 30% leaded bronze — aircraft quality bearings and castings — **ED JENKINS, West Palm Beach, Florida — PHONE: Temple 2-8685.**

EARL E. WOODLIFF
Foundry Sand Engineer
Consulting . . . Testing
14611 Fenkell (5-Mile Rd.)
Detroit 27, Michigan
Res. Phone VErmont 5-8724

WANTED TO BUY

WANTED

1200 Pound Brass Melting Furnace. Must be Stroman Sklenar type, gas fired, complete with burners and blower. **Box G-101 W, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

POSITION WANTED

METALLURGIST-SALESMAN, with following in ferrous and non-ferrous industry, seeks challenging sales position. Experienced in Research-Technical service; last 10 years as Sales Manager. Free to travel and re-locate. Presently employed as Works Manager, non-ferrous foundry. **Reply Box G-100 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

LINES WANTED

LINES WANTED

Nationally known, well established foundry supply house wants to add new lines for its aggressive sales force to sell to the entire foundry industry. Interested parties write to **Box G-103 L, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

DIETERT DETROIT

automation equipment for production sand systems

Sand, Core, Shell and Mold Testing Equipment

CARBON and SULFUR DETERMINATORS

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9330 ROSELAWN AVE.
DETROIT 4, MICHIGAN

Circle No. 149, Pages 129-130

The Editor's Forum . . .

The importance of trading ideas and opinions was brought into sharp focus at the recent Chapter Officers' Conference held by the American Foundrymen's Society. This annual conclave brings together the most representative group of metalcasters in the country today—chairmen and vice chairmen of 47 chapters strategically located in the most important centers of the foundry industry.

Conversation and the free exchange of ideas pointed up the growing attitude of cooperation developing throughout our industry. Not too many years ago foundrymen were reluctant to share trade "secrets" and help fellow metalcasters in other shops. In fact, most skilled artisans, foremen, and superintendents jealously withheld every fragment of their frugal knowledge from their fellow workers. This attitude bred stagnation and decadence into the foundry industry. Fortunately, before atrophy set in, metalcasters made an about-face to salvage a nearly moribund industry.

At the conference, a panel discussed some of their most successful local-level meetings. One of the most popular proved to be a "casting clinic" night when members brought their problem castings to the meeting for open discussion. Competitors helped competitors relocate risers, re-dimension gates, and redesign castings—something unheard of years ago.

A few years ago foundrymen would have refused to admit they had trouble making a casting or ever poured a pound of scrap. Now they share problems as well as solutions.

Management interest are now receiving more attention in programs. For instance the Wisconsin Chapter invited four purchasing agents to discuss: "Are Customers Getting What They Want?" Metalcasters are too often immersed in solving their own problems and forget that customers also need help.

What does this mean to the metalcasting industry? It means our industry has gained a technical maturity that ranks with competitive processes and materials.

Jack H. Schaum

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"A.W." PIG IRON is always available for immediate shipment from our substantial stocks. You're assured of good service on any size order.

Close control of A.W. production techniques also assures you consistent, uniform quality for efficient cupola operation.

Basic steel producers ourselves, we are well versed in metallurgical needs . . . can readily supply you with the correct grade.

Alan Wood services are available to you at all times, including free use of our laboratory for testing and checking castings. Let us show how we can help.

For more information, write Manager, Foundry Coke and Pig Iron Sales.

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AMERICAN IRONMASTERS FOR MORE THAN 135 YEARS

Circle No. 151, Pages 129-130

YOU POUR CLEANER IRON EVERY TIME . . .

if you use *Famous* CORNELL CUPOLA FLUX

for Gray Iron and Malleable Iron Foundries

A little Famous Cornell Cupola Flux, added to each cupola charge of iron, purges molten iron of impurities so that you pour clean metal every time. Furthermore, the iron is hotter, more fluid, and sulphur is greatly reduced. Many dollars are saved in cupola maintenance, too. Digging out is easier as drops are cleaner and bridging over is practically eliminated.

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